

Familial Influences in Social Class,
Educational Level and Intelligence

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Abstract The present dissertation comprises 5 studies, all published separately. The last and most conclusive of these studies could be summarized in the following way: 28 pairs of separately adopted brothers were found to correlate .47 on an army draft board intelligence test and .38 on an educational attainment scale. 64 pairs of separately adopted half-brothers correlated .22 on the intelligence test and .00 on the education scale. For 24 pairs of genetically unrelated males adopted together, the corresponding correlations were .02 and .43. These results are compatible with the interpretation that, whereas familial resemblance in intelligence is primarily genetic in origin, resemblance in educational attainment has both genetic and familial environmental components.		
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Familial Influences in Social Class,
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Thomas W. Teasdale

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No-one, it has been said, is an island, and this may be especially true of the scientific researcher whose activities are embedded in a social context. The present work owes much to many people and part of my satisfaction in completing it is in now being able to thank the principal figures behind it.

I am doubly indebted to Professor Fini Schulsinger, first because he contributed, more than anyone else, to the creation of the unique adoption register from which all of my material derives, and second because of his forbearance and encouragement, as my employer, while I indulged my own scientific curiosity in studies using the register. I am also indebted to my coauthors, Drs. David R. Owen and Thorkild I. A. Sørensen without whose collaboration the individual studies might have been completed much more quickly (and, of course, much less well) or might not have been completed at all. The extent to which the individual studies form the cohesive progression required of thesis work is due to the sustained guidance of Professors Hans Sjöbäck and Gudmund Smith. Dr. Åke Hellström was generous in his sound critical appraisal of earlier drafts of the overview article. At a personal level I need also to thank Dr. Josef Parnas in Copenhagen and Valdimar Eriem in Lund for their sympathy and understanding in listening to the day-to-day agonies and ecstasies of this particular pilgrim's progress.

Finally, a thesis on familial influences would obviously be incomplete without an acknowledgement of my own family, both parents and siblings. The present work is, in the broadest perspective, very much a result of their 'influences'.

The thesis is based on the following five publications.

1. Teasdale, T. W. (1979). Social class correlations among adoptees and their biological and adoptive parents. Behavior Genetics, 9, 103-114.
2. Teasdale, T. W., & Owen, D. R. (1981). Social class correlations among separately adopted siblings and unrelated individuals adopted together. Behavior Genetics, 11, 577-588.
3. Teasdale, T. W., & Owen, D. R. (1984a). Social class and mobility in male adoptees and non-adoptees. Journal of Biosocial Science, 16, 521-530.
4. Teasdale, T. W., & Sørensen, T. I. A. (1983). Educational attainment and social class in adoptees: Genetic and environmental contributions. Journal of Biosocial Science, 15, 509-518.
5. Teasdale, T. W., & Owen, D. R. (1984b). Heredity and familial environment in intelligence and educational level - A sibling study. Nature, 309, 620-622.

The degree to which individual psychological differences, in particular those relating to intellectual ability and achievement, result from genetic predispositions and familial environmental influences has been among the most vigorously disputed topics within psychology (Eysenck & Kamin, 1981), on occasion attracting interest from a variety of other academic disciplines (Block & Dworkin, 1976). The point at issue is, at least superficially, a simple one and rests on two empirically established facts.

First, individuals differ from one another in many psychological characteristics and maintain a considerable consistency in such characteristics across long periods of time. Even those who would question such consistency with respect to many personality characteristics (e.g. Mischel, 1981) usually acknowledge this to be true of intellectual ability, the stability of which across many years is well documented (Bloom, 1964). Second, differences between members of the same family are often less than they are between unrelated individuals.

Familial resemblances are a prerequisite for proposing that genetic factors account for any proportion of individual differences, but under normal circumstances genetic similarity is confounded with the similarity of a shared family environment, and such environments may differ importantly between different families.

The objectives of the present overview are:-

1. to consider critically the research methods which have attempted to overcome this confounding.
2. to review the literature, especially that based upon such methods, bearing upon familial influences on three specific psychosocial characteristics, namely - social class, educational level, and intelligence.
3. to outline, in relation to such literature, the findings from the five empirical studies comprising this dissertation.
4. to offer, in conclusion, an integrated interpretation of these findings.

1. Research Methods

Francis Galton (1883/1973) is generally acknowledged as having been the first to have employed a systematic means whereby genetic and environmental similarity may be distinguished, i.e., by the comparison of monozygotic (MZ) and dizygotic (DZ) twins, having recognized the distinction between them. The former, as is now known, are genetically identical whereas the latter differ, on average, in 50% of their genes, as do parents/children and non-twin siblings. To the extent that both MZ and DZ twins tend to correlate on any given characteristic, then familial influence on that characteristic is implicated. To the extent that the correlation for MZ twins exceeds that for DZ twins, it is argued, the familial influence is genetic in origin. More specifically, the simple genetic expectation would be that the MZ correlation should be twice that of the DZ.

The twin method has remained a popular research tool (Mittler, 1971). As Lykken (1982) points out, twins are usually readily identified, often indeed registered, and are generally co-operative in volunteering as subjects for study. The method is, however, not without its disadvantages. Twins are a rather unique phenomenon; they experience both prenatal and postnatal environments different from those of non-twins. Thus, some of this manifests itself in the frequent finding that twins typically have lower mean IQs than non-twins (Record, McKeown & Edwards, 1970). This may make the generalization of results from twin studies hazardous. A specific example of the special environmental factors which can affect twins is the 'transfusion syndrome' which involves blood transfer from one MZ twin to the other in utero. Munsinger (1977) has claimed that this leads to a discrepancy between the two MZ twins which can later be detected in IQ differences. His claim has been disputed (Kamin, 1978) but the point to be made here is that if such an environmental difference did exist between some MZ twins it would constitute an environmental factor of no relevance to the 97% of the population who are the result of single births.

A second problem is that in any twin study which involves twin pairs varying in age, and measured in some aspect which is age related (as, for instance, ill-standardized psychological tests are prone to be), an artificial correlation between the twin pairs will emerge. This will overestimate the familial contribution to the variance of the measure and, where only MZ twins have been studied (e.g. Juel-Nielsen (1965), Newman, Freeman & Holzinger (1937)) will overestimate the genetic contribution to that variance.

The most important difficulty confronting twin studies is the continuing disagreement as to whether it is valid to attribute the typically greater similarity of MZ twins to genetic causes. Critics (e.g. Goldberger, 1977) point out that MZ twins may share a more similar environment than do DZ twins and there is some evidence that, among MZ twins, those who report a more similar environment are also more similar in their behavioral characteristics (Eynsenck & Kamin, 1981).

The most elegant solution to this difficulty has been to find twins who, by whatever accidents of fate, have not shared the same rearing environment. Such individuals are, however, extremely rare. In a recent review, which included several case reports of single pairs, Farber (1981) enumerates only 124 pairs in the world literature. To this number should be added 27 pairs and one set of identical triplets included in a to date only partially reported study by Bouchard (1984). The standard errors associated with correlations based upon small numbers are necessarily large.

Comparatively easier to find are individuals reared in families to whom they are genetically unrelated. The most usual manner by which this otherwise rare situation arises is adoption. As a legal institution by which a child is reared by parents other than, and unrelated and unknown to, its biological

parents, adoption is a comparatively new and perhaps transient phenomenon in the welfare states of the Western developed world.

The principle of adoption studies is that the extent to which adoptees resemble their biological parents in any characteristic should reveal the degree of genetic contribution to that characteristic. Conversely the extent of resemblance to the adoptive parents should be attributable to the effect of the familial environment. One of the major problems in conducting adoption studies is that information on the biological parents is often unavailable. Thus, for example, in one of the first attempts to elicit the participation of biological fathers, a recent study (DeFries, Plomin, Vandenberg & Kuse, 1981) succeeded in securing the cooperation of only 20%. Some adoption studies therefore have collected data on adoptees and adoptive parents only, comparing their degree of resemblance with that found between 'normal' parents/offspring (e.g. Burks, 1928, and Leahy, 1935) or between the adoptive parents and any biological children they may have (e.g. Scarr & Weinberg, 1977). In this case the rationale is that if the degree of resemblance proves to be the same in both cases then that resemblance must be attributable to the familial environment rather than to genetic factors. Although this reasoning may well be correct, its corollary - that a lesser degree of resemblance between adoptive parents and their adoptive children than between 'normal' parents and children necessarily implicates genetic factors - is perhaps unwarranted. Such a finding would certainly be predicted from a hypothesis of genetic factors but could also be accounted for by any form of 'estrangement' (Kamin, 1974) of adoptees from their adoptive parents. In terms of methodology one might compare the study of adoptees and their adoptive families with the clinical trials of a new drug in which neither the physician nor the patient is blind with respect to drug/placebo condition. The value of adoption studies is very much restricted unless there is information on the biological parents.

Even when information on biological parents, at least the mother, is available, adoption studies must contend with three other potential confounding factors. First, adoptions do not usually immediately follow birth and the biological mother may thus contribute to the early environment of her child. Some early adoption studies (e.g. Freeman, Holzinger & Mitchell, 1928) are especially handicapped by including adoptions taking place as late in the life of the child as five years. Even when adoption takes place at a very early age it remains conceivable that the uterine environment during pregnancy may make some important contribution. A second consideration is that adoptive agencies, rightly or wrongly, often act in the belief that behavioral characteristics are heritable and therefore attempt to find adoptive parents with characteristics matching those of the biological parents relinquishing a child for adoption. This practice reintroduces a correlation between genetic and familial environmental influences and makes any similarity between the adoptee and either type of parent ambiguous. Although discussion of this crucial phenomenon features prominently in the adoption literature (e.g. Ho, Plomin & DeFries, 1979) it seems surprising

that there appear to be no studies in which the adoption agencies themselves have been questioned about their selective placement policies. The third consideration is that if the adoptive parents are given information about the biological parents then this may create expectations which lead to a self-fulfilling prophecy, positive or negative, concerning the child. Attempts to demonstrate that teachers' expectations (manipulated experimentally) can influence children's intelligence and performance, have not been well replicated (Rosenthal & Jacobsen, 1968; Elashoff & Snow, 1971) but the argument is still voiced that the family environment, being more pervasive and longer-lasting, could exert such influence. However, the only available evidence fails to support this argument. Horn, Loehlin, and Wilnerman (1982) found that correlations in IQ between biological mothers and their adopted-away children were not greater where the adoptive parents had been given information on the intellectual status of the mother than where the adoptive parents had been given no information.

In conclusion one should note that twin and adoption designs are not identical in the evidence they can provide. Both can begin by confirming familial similarities and both can further indicate the importance of genetic contributions to such similarities. Theories concerning these contributions would require support from both types of study. However, the familial environmental factors tending to make twins similar to each other are probably stronger than those leading to similarities between parents and offspring, or between non-twin siblings. It should furthermore be emphasized that whereas both twin and adoption studies aim at detecting factors which contribute to resemblance between family members, some familial environmental factors may operate to decrease this resemblance, e.g. birth order effects (Belmont & Marolla, 1973).

2. Psychosocial Characteristics

Just as genetic and familial environmental influences constitute the independent variables in the empirical studies to be presented, social class, educational level, and intelligence constitute the dependent variables.

Social Class

Social class is still widely regarded as one of the most fundamental and ubiquitous ways in which individuals differ. Hierarchical organization and dominance systems are recognizable in most species of social animals (Wilson, 1975; Hinde, 1974) and are particularly elaborate, although also more volatile, in non-human primates (Goodall, 1971). Ironically, the earliest appearances of human civilization permitted a more rigid structuring of such organization with the rise of urban society and the division of labour (Childe, 1955). Thus, at a very early stage in human cultural evolution, social status came to be associated with occupation. The earliest of sophisticated human cultures, however, were characterized by class systems with sharp stratification and with comparatively little mobility,

either within the lifetime of an individual or across generations of different individuals. Class was thus 'ascribed' at birth rather than 'attained' in adult life. The feudal system of medieval Europe was representative of this style of social organization and remnants are still to be seen in the Hindu caste system surviving in modern India.

Following the industrial revolution political theorists, notably Marx, saw social class in terms of relationship to means of production, with a broad dichotomy between a bourgeois class who invested capital and a working class who invested labour. The twentieth century has witnessed an increasing differentiation and more permeable boundaries, and also a reduction in absolute differences in living standards and other consequences of social class. This reduction led to the view held by some that a classless society had been achieved.

That such was not the case was demonstrated by a pioneering study conducted by the U.S. National Opinion Research Center which also succeeded in producing a modern operational definition of social class (Reiss, 1961). A large number of individuals selected to be representative of the general population were asked to rank occupational titles according to 'prestige'. The results showed a considerable unanimity in the status ascribed to occupations, a unanimity which was independent of such rater characteristics as age, sex, and own occupation. This study and its findings were replicated in Denmark by Svalastoga (1959). Brown (1965) has pointed out that it is inappropriate to consider social classes as homogeneous strata since the underlying variability appears to be continuous. Nonetheless it would probably also be inappropriate to attempt to quantify social status, as defined by occupation, to a greater resolution than the five to nine point scales which are now in widespread use.

Psychology has generally been concerned with the effects of social class as an independent variable upon differences in attitudes, perception, etc., rather than seeking to account for social class differences as dependent variables themselves. The degree to which social class has remained familial has, however, been the subject of several large-scale sociological investigations, the findings of which have yielded generally rather stable values. Based upon a representative national sample of over 20,000 adult U.S. males, Blau and Duncan (1967) reported a father/son correlation of .405. Similar early studies in Denmark (Svalastoga, 1959) and in Britain (Glass, 1954) reported correlations of .45 and .48 respectively. The Danish study included both sexes of offspring. More recently Sewell and Hauser (1976), in a longitudinal study of almost 2,000 Wisconsin high school graduates, reported a father/son correlation of .268. Finally Olineck (1977) reported the social class correlation of 346 pairs of adult brothers to be .31.

All of the above studies consider the possibility that both genetic and familial environmental mechanisms might operate to produce these familial correlations in social class but there

has been only one study aimed at distinguishing the two mechanisms. This study used the twin method. Behrman, Hrubec, Taubman and Wales (1980) accessed a U.S. twin register to obtain adult social class data on approximately 1,000 MZ pairs and 1,000 DZ pairs. All of whom were about 50 years old and male. The MZ correlation was found to be .429 and the DZ correlation .205. The absolute values of these two correlations suggests a lesser degree of familial influence upon social class than do the above studies. They also suggest, however, within the limitations of the twin method discussed above, that such familial influence as exists may be primarily genetic rather than environmental in origin (since the MZ correlation is twice the DZ).

Educational Level

In contrast to social class, educational level can be considered only to have a comparatively short history, especially in terms of the significance attached to it by society. This significance has developed in the wake of the societal changes which led to 'attained' rather than 'ascribed' social class structure. It is otherwise almost paradoxical that the twentieth century, having seen so notable a narrowing of the range of educational levels, nonetheless has also come to invest with importance such variation as remains. As recently as a few centuries ago advanced Western societies encompassed educational levels ranging from illiterates to polymaths (e.g. Leibniz - the last person, according to Bertrand Russell, whose scholarship encompassed all scientific knowledge of his age). The present century has seen a substantially expanded allocation of resources to education, with respect to both minimum levels and specialization. These trends have been fuelled by cultural and technological developments and in turn have further contributed to those developments.

Modern educational systems have two objectives. First, obviously, they transmit culture, in the broadest sense, from one generation to the next by instruction. This encompasses ethical, physical, and social aspects but with, perhaps, especial emphasis on intellectual aspects. In this aspect education aims at instilling not only specific knowledge but also a general facility for rational thinking. Second, educational systems necessarily operate to grade and select individuals according to their attainments within the system.

It is this latter function of educational systems which provides another contrast to social class in that educational level may be quite objectively defined, most studies measuring it as rungs on the educational ladder, i.e., number of years of education. Jencks (1972), in support of this definition, noted that the varying quality of different schools appears to have little importance by comparison.

Although social class was initially defined in terms of prestige, without explicit reference to educational level, the relationship between the two factors is intimate. In Jencks's words "trying to invent a status index that does not take educa-

tion into account is like trying to invent a standard of living index that does not include income" (Jencks, 1972). Blau and Duncan (1967) noted that educational level is the single best predictor of adult social class ($r=.595$), a finding replicated by Sewell, Haller and Ohlendorf (1970) who reported the same correlation to be .62. Blau and Duncan noted further that the relationship appeared to be increasing in that they found stronger correlations between educational level and social class for the younger men in their sample than for the older. They recognize, however, that this trend might rather reflect a decreasing importance of educational level with increasing age.

Familial correlations in educational level are generally greater than they are for social class. Thus Blau and Duncan (1976) and Sewell and Hauser (1967) report father/son correlations of .453 and .306 respectively and Olneck (1977) found a correlation between brothers of .55.

Jencks (1972) proposes five reasons why children of successful parents should obtain better educational credentials than children of less successful parents: first, that their familial environment will be conducive to the intellectual skills needed to do well at school; second, that they are more likely to have genes that facilitate school success; third, that they seldom have to work or borrow money to attend college (a factor of more relevance in some countries, e.g. U.S.A, than in others, e.g. Great Britain); fourth, that they may feel obligated to stay in the educational system, whether or not they have any aptitude for it; fifth, that they may attend better schools, although as stated above Jencks feels able to discount this factor.

As with social class, there has been very little empirical effort to distinguish the two kinds of familial influence on educational level, the genetic, corresponding to Jenck's second reason above, and the environmental, corresponding to the first, third and fourth reasons. Behrman et al. (1980) reported an MZ correlation of .764 and a DZ correlation of .545. This again suggests a stronger familial effect upon educational level than upon social class, and, furthermore, that much of the familial effect is genetic in origin.

Intelligence

In contrast to both social class and educational level, intelligence is a theoretical concept created within an academic discipline, namely psychology. Since its inception it has been surrounded by controversy at various levels, one of the most fundamental of which is that concerning definition. Thus for example, Block and Dworkin (1976) raise the positivist objection to intelligence that, since no satisfactory definition of the concept can be agreed upon, the concept can have no meaning. Counter to this it has been argued that it is a misunderstanding of scientific methodology to demand precise definition of a theoretical concept at too early a stage of investigation. In this vein, Jensen (1969) likens the present stage of investigation of intelligence as a dimension of individual differences to that of

investigations of electrical phenomena during the last century, when an attempt to define electricity in any way other than operationally would have been premature, and indeed perhaps a hindrance to the progress of understanding.

Clearly, however, an operational definition is required for an empirical psychology and this is the sense of Boring's celebrated dictum that 'intelligence is what is measured by intelligence tests' (cited in Herrnstein, 1973). Vernon (1979) notes that the success of Binet in constructing the first quantitative intelligence tests lay in anchoring them to the non-controversial observation that, however intelligence is to be defined, it certainly increases with age in children. From this starting point it was a comparatively simple step to scale and calibrate intuitively devised mental tests according to the proportion of children of different ages who could solve them. Extrapolation to adults, for whom intelligence does not appear to vary dramatically with age, required a different metric and for this purpose adult tests are usually normed and scaled to yield a Gaussian distribution.

A second, long-discussed, issue within the field of intelligence is whether the concept is appropriately viewed as unitary or as multi-dimensional. This discussion has a history extending back to the inception of intelligence tests with Spearman's proposal of an overriding general factor ('g') and Thurstone's model of six distinct primary mental abilities (see, e.g., Anastasi, 1982). The view that everything commonly understood as intelligence can be measured along a single dimension has almost always been unpopular (Jay Gould, 1981; Gardner, 1983). The difficulty for current multifactorial theories is the profusion of factorial systems proposed, ranging from two factors, e.g. verbal/performance (Wechsler, 1958) and fluid/crystallized (Cattell, 1971) to 120 (Guilford, 1967). Furthermore, in all systems hitherto proposed, factors may only be identified by the mathematical rotation of factor loadings derived from matrices of correlations between subtests. However, almost all subtests included in common intelligence test batteries correlate with each other to a greater or lesser extent. Thus the hypothesized factors can not be directly measured independently from each other. While this does not invalidate factorial approaches, the persistence of correlations between often widely diverse subtests continues to give a reasonable pragmatic value to a unitary approach.

A third issue is the relationship between intelligence and educational level. Binet's intelligence tests were developed within, and to serve, an educational system, and subsequent intelligence tests have been validated principally against educational attainment. Furthermore, as stated above, educational systems aim at improving childrens' reasoning ability which perhaps lies at the heart of what is measured by intelligence tests. The opinion is therefore often expressed that there is no fundamental difference between intelligence and educational attainment. If variation in what is measured by intelligence tests were solely the product of what is acquired within the

educational system then this claim would be true. Any evidence for genetic influences on intelligence test scores argues against this claim. For so complex a mental characteristic as intelligence, that part of phenotypic variability which results from genetic variability cannot be perfectly mimicked by the effects of environmental variability. Therefore if intelligence, as measured by IQ tests, is to an appreciable extent the result of genetic factors, then educational attainment, which is clearly more malleable through environmental influences, cannot be precisely the same entity. Thus the high degree of correlation invariably observed between intelligence and educational level does not necessarily imply that they are fundamentally identical.

Familial resemblance in intelligence, generally measured as a single IQ score, is well documented. In a recent review of the extensive literature Bouchard and McGue (1981) reported that the median correlation for parent/offspring was .385 (based on 32 studies involving 8,433 pairs) and for siblings (other than twins), .45 (based on 69 studies involving 26,473 pairs). Studies attempting to distinguish the relative influences of heredity and familial environment, both of which could be responsible for such correlations, have also been numerous, involving both twin and adoption designs.

Bouchard and McGue (1981) report a median correlation for MZ twins of .85 (34 studies, 4,676 pairs) and for DZ twins, .58 (41 studies, 5,546 pairs). The difference between these two correlations provides, within the possible limitations of twin studies discussed above, strong *prima facie* evidence for genetic contributions to intelligence. The correlation for MZ twins comes close to the reliability limits of current intelligence tests (Anastasi, 1982). At the same time some shared environmental mechanisms are also implicated. The correlation for DZ twins lies above that for non-twin siblings, and also above .5 which, on the assumption that parents are not overwhelmingly similar in intelligence, represents the upper limit of an expected correlation based on hereditary mechanisms alone. This could therefore be the result of a more similar common environment for DZ twins, although, as discussed earlier, this would represent another instance of a special environmental factor irrelevant to non-twin relationships.

Adoption studies, though fewer in number, have also suggested that genes play an important role in producing familial resemblances. Some of the earliest evidence consisted of the demonstration that the correlation between adoptive parents and their adoptive children is less than that between parents and children generally; Bouchard and McGue give the median correlation for the former as .18 (6 studies, 1,397 pairs). As stated above, however, the inference of genetic factors, by default, from such findings may not be legitimate, since the 'familial environment' of adoptees may differ from that of non-adoptees.

More direct evidence for genetic factors comes from the correlations between adoptees and their biological parents. There

have only been three such studies, all yielding correlations between biological mothers and their adopted-away children. Snygg (1938) reported a correlation of .13 (based on 312 pairs), Skodak and Skeels (1949) reported .38 (100 pairs) and Horn, Loehlin, and Willerman (1979) reported .31 (345 pairs). Bouchard and McGue (1981) list a fourth study, that of Fisch, Bilek, Deinand and Chang (1976) but the inclusion is erroneous. The study reported a correlation (.08) between adoptive mothers and their adopted children.

Most direct of all has been the evidence from studies of MZ twins reared separately. Of the four studies in the literature one, that of Burt (1966), was called into question by Kamin (1974) owing largely to the improbability of a correlation, .77, for a group intelligence test having remained constant throughout a steady increase in the number of pairs reported in Burt's publications between 1943 (15 pairs) and 1966 (52 pairs). That Burt was guilty of fraud, at least in his later years, has since been placed beyond dispute by a biographer who had access to his private diaries (Hearnshaw, 1979).

The momentum of Kamin's critique of Burt's work carried over to an evaluation of the remaining three studies of separated MZ twins. Newman, Freeman, and Holzinger (1939) had reported a correlation of .67 (19 pairs), Juel-Nielsen (1965) reported .62 (12 pairs), and Shields (1962) reported .77 (34 pairs). Kamin found methodological flaws in all three of these studies, mainly that the rearing environments of the separated twins had been similar, and both Taylor (1980) and Farber (1981) have claimed, on the basis of secondary analyses, that these environmental similarities could account for the resemblance in IQ. Fulker (1975) and others have however pointed out that the similarities involved in these studies are not greater than those commonly experienced by cousins, whose resemblance in IQ is substantially less - Bouchard and McGue (1981) report a median correlation of .145 (4 studies, 1,176 pairs).

Recently the results of a new study of separated MZ twins have been partially presented. Bouchard (1984) has reported on 27 pairs and one set of triplets who on average had been separated earlier in life, and reunited later, than in any of the three previous studies. The correlation in IQ for these twins was .71. The view that there are no, or only negligible, genetic contributions to differences in intelligence seems therefore to be no longer tenable. Conversely, the view that some environmental influences on IQ are to be found within the family setting has never been disputed, although some reviewers (e.g. Munsinger 1976) have suggested that such influences are only minor.

3. The Present Empirical Studies

The five studies which follow this introduction are all based upon the Danish adoption register which, by almost an order of magnitude, is the largest adoption register compiled for research purposes. Furthermore, in view of the steady decline in number of adoptions in those Western countries where the prac-

tice has been common, it may well prove to be one of the last, giving an additional importance to the studies deriving from it. It comprises all of the 14,427 non-familial adoptions recorded in Denmark between 1924 and 1947. Danish adoption law since 1914 has distinguished sharply between familial adoptions (e.g. where a husband adopts his wife's children by a former marriage) and non-familial adoptions, which are required by law to be negotiated through an authorized intermediary without direct contact between the parties involved (viz. the biological and adoptive parents).

The five studies have been conducted over a six year period and have largely been the result of the pragmatic exploitation of available data. The theoretical interpretations which are offered here have thus evolved post hoc in the light of the results themselves.

Study 1 (Teasdale, 1979) involves the entire register of 14,427 adoptions. It presents the basic demographic data, ages and sex distributions, and introduces the Social Class scale which is used throughout the five studies. The scale lays special emphasis on educational requirements, and furthermore attributes to a person in a training occupation the social class attained when that training is completed. For these reasons the scale does not correlate substantially with age. Nor are there large mean sex differences, although the variance for females is rather smaller than that for males, and fewer women than men have a recorded occupation. At the time the adoptions took place adopting mothers were expected not to have a job outside the home.

The study reports correlations between parental, both biological and adoptive, and offspring social class. Thus in two respects the study is unlike most of the studies of adoptees considered above. First, information is available on a substantial proportion of biological fathers, and second the adoptee measure, like that of the parents, is recorded at an adult age.

The study examines the influence of two of the most critical aspects of adoption, as discussed earlier; that of late placement, which could result in an early postnatal environmental influence of the biological parents (more probably the mother) on the child; and that of selective placement, i.e. the policy of adoption agencies to place children in adoptive homes according to the characteristics the children are anticipated to develop, these anticipations being formed from a knowledge of the biological parents.

If resemblance between biological parents and adoptees came about because of postnatal influences prior to adoption then correlations between adoptees and the biological parents would be lower for adoptees transferred to their adoptive homes immediately after birth than for adoptees in general. The results of the study show this, however, not to be the case.

Selective placement, by contrast, can artificially inflate the correlations between the adoptee and both biological and adoptive parents. Since this study involved such large numbers it was possible to examine the adoptee/biological parent correlations within each stratum of adoptive parent social class. This technique constitutes a much more rigorous control of the 'covariate' social class than partial correlation provides. The results showed that the adoptee/biological parent correlations were diminished, but only marginally, by such stratification. Corresponding results were found in the adoptive father/adoptee correlations stratified for biological father social class.

It might be noted in passing that there was no tendency for the correlations between the biological parents and the adoptees to be higher where the adoptees had been adopted into higher social class homes. This might otherwise have been predicted from Scarr's (1972) finding, derived from a twin study, that IQ heritability is greater in higher social class environments than it is in lower.

This study also notes that some degree of the adoptee/adoptive father resemblance comes about because the adoptee enters the same trade or profession as his or her adoptive father. Jencks (1972) had suggested that this tendency might be an important contributor to familial resemblances in social class. The study did not, however, speculate on the nature of the genetic transmission involved, other than to report, somewhat tangentially, the correlation between the social class scale and an intelligence test, the Børge Prien Prøve (BPP, the statistical properties of which are described by Rasch (1980)).

Study 2 (Teasdale & Owen, 1981) began from the unexpected but useful observation that, in the years covered by the adoption register - 1924-1947, there had been numerous instances of the same biological mother and/or father adopting away more than one child, and correspondingly instances of adoptive parents adopting more than one child. The presence of such siblings among the 14,427 adoptees provided an opportunity for an independent replication of the findings of Study 1. It proved possible to trace large numbers of genetic full and half siblings as well as siblings by adoption. Unfortunately (for research purposes) only seven pairs of separated same-sex twins were found. The probability is that, at most, four of these would have been MZ pairs and one pair had already been included in the study by Juel-Nielsen (1965). The twins were therefore not used.

We predicted that the correlation in social class for genetic full siblings would be approximately the value found in Study 1 for biological parents and adoptees since in both cases the relationship is of first degree. This prediction was confirmed. A genetic model would, however, also predict correlations between second degree relatives to be half those for first degree relatives and we failed to find such correlations among either paternal or maternal half siblings. This may have been due to sampling error since, in a later study (Teasdale, Sørensen & Owen, in press), involving larger numbers of half siblings, we have found such correlations.

This study again considers the potential effects of late placement - which again was found to play no role in the correlation between separately adopted full siblings - and selective placement. It is an almost unique aspect of this study that selective placement would be expected, a priori, to be of minimal importance. This is because the genetically related pair members were both adopted away at separate times into separate adoptive homes. This means that the relevant estimate of environmental correlation between separate genetic relatives is not, as is usually the case, that between the biological and adoptive parents, but that between the two sets of adoptive parents. The latter correlation would be at most the square of the former. Thus, for example, if the adoption agencies were succeeding in matching the social class of the biological and adoptive parents to the order of .15, as was found in Study 1, then the statistically expected correlation between the social classes of the homes into which two separated full siblings were adopted would be $.15^2 = .0225$. For half siblings this correlation would be even smaller. The correlations between adoptive fathers' social class observed in Study 2 are somewhat larger than these expected values but are nonetheless definitely smaller than .15. This point is of critical importance in view of the weight attached to selective placement by those sceptical towards 'hereditary' interpretations of similarities between environmentally separated genetically related individuals (e.g. Kamin, 1974; Taylor, 1980; Farber, 1981).

Correlations between unrelated individuals reared together were also found in Study 2. It is noteworthy that these correlations are substantially greater for pairs of individuals of the same sex than for opposite sex pairs. This effect has also been observed in another study including unrelated individuals reared together (Teasdale, Sørensen & Owen, in press). This suggests that role modelling, and perhaps sibling rivalry, is operating principally for same sex siblings. By contrast parent/offspring correlations are not obviously sex-dependant; the effect of the adoptive father is almost equal for both sexes of adoptees (see Study 1).

Study 3 (Teasdale & Owen, 1984a) is principally concerned with the comparison of adoptees with the general non-adoptee population, the dependent variable again being social class. The issue of comparability has two aspects. First, both genetic and familial environmental models would make predictions about differences and similarities between adoptees and non-adoptees dependent upon parental characteristics, in the case of adoptees both biological and adoptive. These predictions may be expressed in terms of both correlations and group mean differences. For instance, a model which assumed no genetic influence on social class might (simplistically) predict i) a correlation between adoptive parent and adoptee equal to that between non-adoptive parents and their offspring, and ii) a mean for adoptees which had regressed back towards the population mean by as much as that experienced by non-adoptee offspring of parents with the same social class as the adoptive parents. In fact, the results of study 3 were compatible only with a model which included both

genetic and familial environmental contributions. Importantly, however, an additive model did not prove adequate since the multiple correlation of adoptees with both their biological and adoptive fathers was markedly less than the correlation of non-adoptees with their fathers. This might suggest some form of genotype-environmental interaction - although the report also discusses other interpretations.

The second aspect to the issue of comparability is that of extrapolation of findings from adoption studies to the general population. A problem frequently encountered in such studies is that variances prove to be less than in the general population (Loehlin, 1980). Reduced variances on either the biological or adoptive side would result in an underestimate of the contribution from that side. As an extreme example, a study of IQ in adoptees in which all of the biological parents of the adoptees had identical IQs could obviously not reveal any biological parent/adoptee correlation. Study 3 demonstrates a strength of the adoption register as a whole, namely that although adoptive and non-adoptive families differ in their means, they do not differ in their variances and thus no serious underestimation of genetic or familial environmental contributions is occurring.

Study 3 also emphasizes the admittedly only suggestive evidence that genetic influences increase in importance in adoptees with age - at least in the range 25-28 to 35-38 with which the study is concerned. Although this might represent some universal phenomenon of epigenesis (Wilson, 1978) it could also be peculiar to adoptees as a consequence of being reared in environments perhaps discordant with their genetic endowment. Thus it might require some years for them to 'find their level' in adult life, a level which could differ from that for which they have been groomed.

Study 4 (Teasdale & Sørensen, 1983) extends the work of the preceding three studies to include educational level in adoptees, both as a dependent variable predicted by the social class of biological and adoptive fathers, and as an independent variable playing a mediating role in the determination of the adoptees' own social class as adults. The initial population for the study was all of the 5455 adoptees whose adoptions had been granted in Copenhagen.

The major finding of the study, established by a path analytic model compounded from regression analyses, was that the contributions of the social class of both the biological and adoptive father to that of the adoptees had already substantially manifested themselves in the educational level attained by the adoptees. This is despite the fact that educational level accounts for only 28% of the social class variance among male adoptees, and less, 22%, among female adoptees. It therefore becomes easier to speculate on the nature of both the genetic and familial environmental contributions. The interpretation offered here is that the environmental influence represented by the social class of the adoptive father is primarily concerned with motivational characteristics, namely aspiration level and

diligence. Conversely the genetic influence of the biological father is primarily a reflection of the inheritance of intelligence more than of any other psychological characteristic. The report itself is rather more reserved in interpreting the results but it was written before Study 5 was conducted, the results of which support this interpretation.

Study 4 also found, for males but not for females, some small residual direct effects of paternal social class on adoptee social class when the major, indirect, route via educational level had been allowed for. The effect of the adoptive fathers' social class was interpreted as being partly the result of 'following in father's footsteps' on the part of the adoptees, irrespective of their education, in the manner suggested by Jencks (1972). For the biological fathers the residual effect was considered to be similar in origin to that of mobility found in Study 3, i.e. indicative of some belated readjustment in keeping with genetic endowment, or, in the words of T. I. A. Sørensen (personal communication), 'regression towards the genes'.

Study 5 (Teasdale & Owen, 1984b) proceeds one step further than Study 4 to consider the role of intelligence and the degree to which it influences, and is influenced by, educational level.

The adoptee sample for this study was selected from the sibling pairs within study 2, and a control group of non-adoptee siblings was identified from the cohort of 28,879 described in study 3. The intelligence and educational level data derived from military induction records, the intelligence test involved being the EPP referred to in Study 1 (Rasch, 1980). In addition to the correlation and regression methods employed in the previous studies, Study 5 also included a series of biometrical genetic models which perhaps merit a more detailed presentation than space limitations permitted in the original article.

The technique involves partitioning total variance for a population into several hypothetical components, e.g.

$$\sigma^2_T = \sigma^2_G + \sigma^2_E$$

where σ^2_T = total variance, σ^2_G = genetic variance, and σ^2_E = environmental variance. More complex models, including separate components for genotype/environmental interaction and assortative mating etc., may be constructed but these were not found necessary in the present study. When the population comprises sets distinguished by some factor (e.g. members of different families) then the total variance may also be partitioned into a between-set and within-set variance,

$$\sigma^2_T = \sigma^2_B + \sigma^2_W$$

where σ^2_B = between-set variance, and σ^2_W = within-set variance. In the present data, a set is a pair of brothers. How σ^2_G and σ^2_E are partitioned between σ^2_B and σ^2_W depends upon the nature of the relationship. It is customary to partition σ^2_E into a

σ^2_{E2} , an environmental component which is equal for all members of a set but which differs between different sets (i.e. familial environment), and a σ^2_{E1} for all other environmental factors. As an example, the σ^2_{E2} for sets of individuals reared together will, by definition, only contribute to the variance between different sets, σ^2_B , and not at all to differences within sets, σ^2_W . The relative distribution of σ^2_G into σ^2_B and σ^2_W depends on the relationship involved and is, in fact, a simple function of that relationship. Thus, for MZ twins, all of the genetic variance lies between sets, i.e. in σ^2_B , and none of it within sets, σ^2_W . For full siblings, who differ in half their genes, half of the genetic variance lies in σ^2_B , and the remaining half in σ^2_W . For half siblings, who differ in three-quarters of their genes, three-quarters of the genetic variance lies in σ^2_B and only the remaining quarter in σ^2_W . Finally, for unrelated individuals reared together, who share no common genes, all of the genetic variance lies in σ^2_B , and none of it in σ^2_W .

The data in study 5 involved five types of sibling sets, full siblings reared apart, maternal half-siblings reared apart, paternal half-siblings reared apart, unrelated individuals reared together, and a non-adoptee set, full siblings reared together. These five groups yield five σ^2_B and five σ^2_W values. Thus ten values are available to estimate only three parameters, σ^2_G (termed $1/2 D_R$ in the article), σ^2_{E1} , and σ^2_{E2} . A model fitting procedure was therefore necessary, maximum likelihood being chosen in preference to the traditional least squares solution, and seven degrees of freedom remain to test the fit of the overall model. In addition, standard errors are computed for each of the three parameters, yielding a significance calculation for each separately.

The results for intelligence indicate a highly significant genetic component and no significant environmental components. For educational level a genetic component is again present, although less overwhelming, and correspondingly a significant familial environmental effect (E2) appears.

A graphic illustration of these results is shown as intra-class correlations for intelligence and educational level in Figures 1 and 2 respectively. In both figures a dotted line indicates the correlations which would be expected for the adoptee pairs involved in Study 5 on a characteristic totally determined by genetic variance, i.e., .0 for unrelated individuals reared together, .25 for separately reared half siblings, and .5 for separately reared full siblings. Conversely, the broken line in both figures indicates the expected correlations assuming that the correlations usually observed among relatives are due to familial environmental influences, i.e., about .5 for unrelated individuals reared together, and .0 for both half and full siblings reared apart. In both figures the continuous lines connect the observed correlations. As can be from Figure 1 the observed correlations for intelligence lie much closer to the genetic expectations than to the familial environmental ones. Figure 2 shows that neither of the two 'extreme' expectations are in close agreement with the results for educational level,

suggesting some intermediate interpretation involving both factors.

Biometrical genetic modelling and correlation analyses are both concerned only with group variances and, in keeping with an assumption in the model employed here, the five sets of sibling pairs did not differ in their total variances, σ^2_T . They did, however, differ in their mean levels, for both intelligence and educational level, in a meaningful way. Specifically, the set of unrelated individuals reared together had a higher educational level and, to a less marked extent, a higher intelligence, than did the other three adoptee groups (full and half siblings reared apart). This appeared to be the result of the higher social class environments into which they had been adopted, and again testifies to familial environment being a more potent influence upon educational level than upon intelligence.

4. Conclusion

Study 5 ends with two hypotheses. First, familial environment might only impact upon intelligence to the extent that it influences educational level, since it may be what is learned in school, more than what is learned in the home, that is the major environmental variable influencing intelligence. This relates to the 'instructional' function of educational systems discussed above. Second, hereditary variation for whatever central nervous system characteristics are detected by intelligence tests, may be much greater than for any other characteristics that contribute to variation in how far individuals proceed through the educational system. This relates to the selective function of educational systems as described above. The demonstration of genetic influences on intelligence will ultimately rely on the identification of these central nervous system characteristics. This identification should also resolve the issue of the dimensions of intelligence; simply put, intelligence may prove to have as many dimensions as the number of polygenes controlling it.

The argument of indirect effects may be extended to account for the social class findings also. Study 4 found that both the genetic and familial environmental effects upon the adoptees, social class had already substantially manifested itself in their educational level. The genetic influence upon social class consistently found in studies 1, 2 and 3 might also be largely indirect, resulting from a hereditary intelligence setting limits to how far an individual is able to proceed through the educational system, which in turn channels the individual into a corresponding social class. The family environment influence on social class similarly seen in studies 1, 2 and 3 could also operate principally by creating conditions, conducive or otherwise, to the continuation of formal education beyond the minimum school leaving age.

FIGURE 1

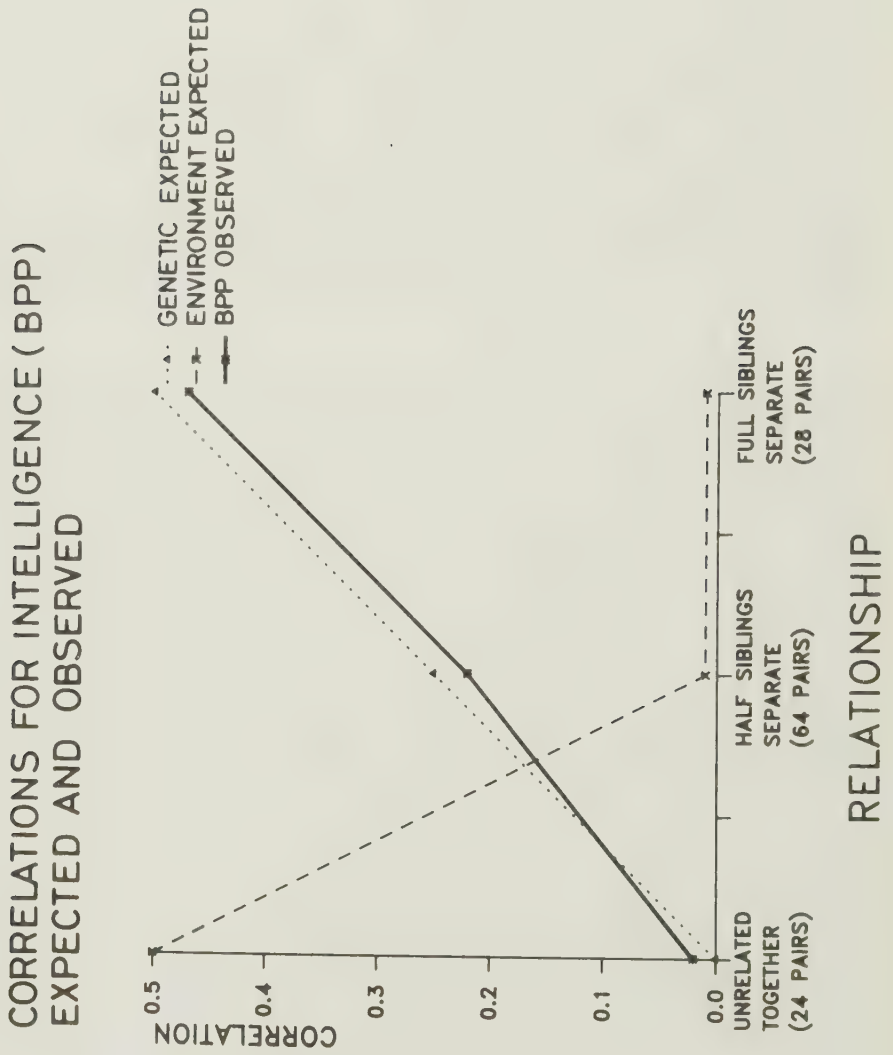
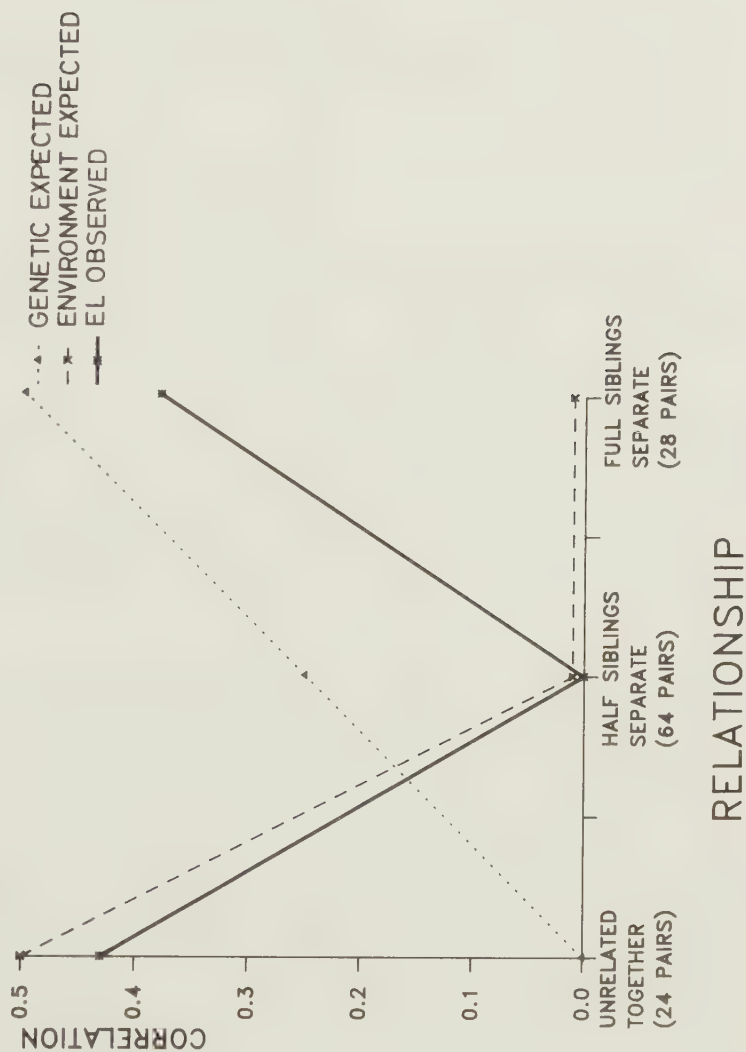


FIGURE 2

CORRELATIONS FOR EDUCATIONAL LEVEL (EL) EXPECTED AND OBSERVED



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Social Class Correlations Among Adoptees and Their Biological and Adoptive Parents

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Positive correlations for SES ratings are reported for a large sample of adoptees and their biological and adoptive parents. The possible effects of selective placement and late placement are examined, and the validity of the SES scale is discussed.

KEY WORDS: social class; SES; adoptees; intelligence; inheritance.

INTRODUCTION

In the continuing discussion of alleged genetic factors underlying phenotypic variance in intelligence, almost all interested parties are agreed that conclusive evidence can alone stem from studies of adoptees. In defining "requirements for a proper study" Lewontin (1975) urges that "most central of all, the study must randomize members of a *genetic* pair over relevant variables. That is, twins must be reared apart, or children raised apart from their parents, or sibs raised apart" (p. 394). As Munsinger (1975) observed in a review of the extant data regarding IQ of adoptees, adoption itself does not necessarily disentangle the influences of genes and environment. If the child is not separated from its biological parents very soon after birth or if the child is placed with adoptive parents similar in salient respects to its biological parents (a factor usually termed "selective placement"), then, to that extent, the *raison d'être* for an adoption study is negated.

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Munsinger rightly concludes that the Texas Adoption Project² (also cited in DeFries and Plomin, 1978) will provide the best data addressing this issue, although it is not without its drawbacks. The results reported to date are obtained from very young children with attendant low reliability, and, in common with virtually all other studies, no information is available regarding the biological father. The existence of direct measures of IQ for the biological mothers, however, is almost unique and most studies have, of necessity, contented themselves with such indirect indices as Educational Level (e.g., Scarr and Weinberg, 1977) and Socio-Economic Status (SES) (e.g., Claeys, 1973).

The use of SES in this way is considered acceptable by virtue of the seemingly warrantable assumption of a positive relationship between SES and IQ. Within this context, therefore, it would appear useful to present the SES correlations derived from an exceptionally large sample of adoptions.

The Copenhagen Adoption Register was compiled by Kety and co-workers (see Kety *et al.*, 1968) from archives made available by the Danish Ministry of Justice. Initially used for studies of the etiology of schizophrenia, it has subsequently proved a rich source of material elucidating genetic contributions to a variety of forms of psychopathology (see Mednick *et al.*, 1974).

Throughout the research emanating from this register a scale of SES has invariably been employed, as a "background" or "matching" variable in the selection of control groups, etc.

The present article reports the correlations for SES ratings among adoptees (AD), their biological fathers (BF), their biological mothers (BM), and their adoptive fathers (AF) and discusses the construction and validity of the SES scale. The size of the material enables in particular detailed consideration of the two critical issues named above, i.e., age at separation and selective placement.

METHOD

The Sample

Kety and co-workers began their research program by examining legal documents relating to all adoptions in Denmark between the years 1924 and 1947. From these they selected the approximately 50% in which, according to official accompanying reports, the adoptive parents were unrelated to the adopted child. In the first instance, the sample was, moreover, restricted to the 5483 such adoptions found in the municipality of Copenhagen, but this number was later extended to cover all of Denmark, for the same time

² Editor's note: the May 1979 issue of *Behavior Genetics* will include the first data by Horn, Loehlin, and Willerman published from this adoption study, "Intellectual Resemblance Among Adoptive and Biological Relatives: The Texas Adoption Project."

period, yielding 14,427 adoptions in all. This latter figure is thus the sample size for the results presented here.

From each record the following information was transcribed: (1) the name and date of birth of all five parties involved, i.e., AD, BF, BM, AF, and AM (Adoptive Mother); (2) the sex of AD; (3) the age at which AD was transferred to the adoptive home; (4) the date of the formal adoption; (5) the occupational titles, where available, for each parental category, BF, BM, AF, and AM; (6) the annual income of AF at the time of adoption.

It must be emphasized that these data are not present in their entirety for every case. In particular, information regarding BF was frequently lacking. Furthermore, only 1% ($N = 127$) of AMs were recorded as having an occupation and this item is therefore not used here.

In 1976–1977, an attempt was made to locate all ADs in an official central Danish register, established in 1968 and covering the entire population, in order to extract present occupation, if any. The search was successful for 91% of cases ($N = 13,194$). Of the remainder, 948 were thereafter discovered, via other channels, to have died or emigrated prior to the establishment of the register, and 285 remain unlocated. For both of these groups no occupational title is available.

From those identified in the register, occupations were obtained for 88% (5888 out of 6700) of the male ADs and for 47% (3643 out of 7727) of the AD females.

THE SES Scale

Svalastoga (1959) reported the outcome of a large-scale and carefully representative Danish survey in which 1000 interviewees were asked to rate a series of occupations according to “prestige.” The results indicated that the 75 occupational titles included in the study could be placed in a clear rank order with remarkably little disagreement among raters, irrespective of their own occupation and sex. The rated titles had been chosen to encompass the widest conceivable range—from shoe polisher to prime minister.

Svalastoga then proceeded to examine the ranking in relation to other variables, e.g., income and education, and thereby established the principles for a nine-level classification of SES.

Mednick and Schulsinger (1965), for purposes of matching subjects in a longitudinal study of children at “high risk” for schizophrenia, adapted Svalastoga’s system to produce an 8-point scale. Practical experience with such special material had suggested that finer resolution was required at the lower end of SES, and rather less was necessary at the top, than Svalastoga’s scale provided. The defining principles for each level are listed here together with examples from the most commonly occurring among the ADs.

0. Unskilled worker: positions requiring no special training and bearing a minimum of responsibility, e.g., cleaner, porter.
1. Semiskilled worker: marginal degree of training or responsibility, e.g., lorry driver, nursing help.
2. Skilled worker: having served an apprenticeship as an artisan but not self-employed, e.g., mechanic, hairdresser; also coded here are shop assistants.
3. Subordinate clerk: performing routine clerical work (or educationally equivalent positions), e.g., secretary, nurse, sales representative.
4. Skilled worker with own business: (or educationally equivalent positions): farmer, bookkeeper, nursery school teacher.
5. Subacademic professions: Requiring education just below that of university level, e.g., school teacher, engineer.
6. Academic professions: requiring university education, e.g., architect, doctor, lawyer.
7. Advanced professional positions: e.g., university professor, chief physician.

The scale has continued to be used to good effect in a number of research projects administered at Psykologisk Institut, Copenhagen, e.g., Wender *et al.* (1973) and Witkin *et al.* (1976).

In order to facilitate the scoring of large numbers of occupations, and to eliminate the need for *ad hoc* assignment of difficult or unusual cases, a reference list is used. This is an alphabetical list, prepared by the Danish Statistics Department and includes over 3000 occupations. To each of these a group of Danish social workers, in collaboration with an American sociologist, have allocated an appropriate SES rank, following the guidelines of the Mednick and Schulsinger scale.

RESULTS

The overall distributions of SES and means for SES and age in each category are given in Table I. The ages for BF, BM, and AF are relative to the birth of the corresponding AD, for ADs the age is as of 1977—the year when their occupational titles were obtained. The proportion of missing data is much higher among AD females and BMs than among the male categories. For the majority of AD females (2351 out of 4084) who have no SES this is a consequence of their being listed as “housewife,” an occupation not rated on the scale. The BMs, however, were overwhelmingly unmarried and many of those without an occupation were probably living at home with their parents. Thirty percent of BMs were under 21 years old.

Table I. Distribution of SES

	SES								Not available	Mean SES	AGE		SES-age <i>r</i>
	0	1	2	3	4	5	6	7			Mean	SD	
AD♂	627	586	1767	999	1010	557	337	5	812	2.72	39.4	8.0	-0.008
AD♀	506	381	460	1588	385	240	83	0	4084	2.55	40.7	8.5	0.101
BF	3278	1239	3743	1248	1545	284	161	8	2921	1.83	29.0	8.7	0.146
BM	4157	366	476	395	87	14	6	0	8926	0.54	24.0	5.4	0.137
AF	2134	1633	3260	1628	3690	859	664	17	542	2.61	36.3	6.5	0.175

The distribution of SES for BM shows a marked predominance of class 0; this is because the scale assigns that value to "domestic servant," a very common female occupation during the period 1924-1947.

It will be observed that the mean SES for ADs lies slightly above that for AF, and that both of these are above BF. This is an effect reminiscent of the Skodak and Skeels (1949) finding that mean IQ for adoptees was much higher than that of their biological mothers. In the present data regression to the mean is presumably playing some part, but, more importantly, differences of mean SES across a generation are likely to be influenced by gross changes in social conditions and technological developments affecting the labor market, for which the BM distribution provides a striking example.

Table I also lists the SES-age correlations for each category. That they are as low as they are is probably the result of two counteracting trends. The tendency for a positive relationship by virtue of advances in status with increasing age is being partially offset, especially among ADs, by the fact that the younger individuals have been exposed both to wider educational opportunities and to a labor market offering a steadily declining proportion of unskilled positions.

Table II presents the interrelationships of the parental categories. In this table and subsequent ones the relationship measures are Pearson product-moment correlations, and in all cases are based on all available

Table II. Intercorrelations of Parental SES Ratings

	<i>n</i>	<i>r</i>
BF with BM	4,531	0.264 ^a
BF with AF	11,094	0.147 ^a
BM with AF	5,358	0.146 ^a

^a $p < 0.01$.

pairs of observations, i.e., all pairs for which both data items were not missing.

The correlations between BF and BM suggests a rather high degree of assortative mating, especially in view of the fact that an estimated 90% of the biological parents were not wed, at least not to each other. By comparison, Plomin *et al.* (1977), also using adoption files, report SES correlations of 0.15 between unwed biological parents and 0.25 between wed biological parents.

The correlations of AF with BF and AF with BM both indicate that some selective placement has occurred in the sample; i.e., the adoption agencies tended to place children into adoptive homes as a function of their biological background. This phenomenon is widespread in adoption studies and necessitates caution in the interpretation of relationships between an adoptee and all classes of parent.

Correlations between ADs and biological parents (BPs) appear in Table III. Wherever possible a midparent (MP) value has been calculated as the average of BF and BM. This has been done because (1) by virtue of the demonstrated assortative mating, the correlations of AD with any BP will overestimate the genetic contribution of that parent, and (2) MP ought, in an elementary genetic model, to correlate better with AD than either BF or BM alone. Since the issue of selective placement is critical an attempt is made to control for this factor by computing the AD-BF, AD-BM, and AD-MP correlations for each level of AF. Thus, for example, the row "AF = 0" represents the correlations between AD and BPs for those ADs who were adopted into SES 0 homes. In this way the confounding covariance of genetic and environmental influences is minimized.

Table IV shows the converse relationship, AD with AF. In controlling for genetic background the SES of BF is used since that is the more frequently available parameter. In view of the frequent absence of this measure, however, the AD-AF correlations are also calculated for those cases where no BF score is available.

It is not generally known how long the ADs remained with their BPs after birth. For the relatively small number selected for detailed study by Kety and others using the register, early history was carefully traced, but for the vast bulk of adoptions it is possible only to set an upper limit on this time period inasmuch as age at transfer to adoptive parents is recorded for only 79% ($N = 11,347$) of cases. The distribution of age at transfer is shown in Table V. It can be seen that 50% of the ADs were transferred to the adoptive home within the first 4 months of life, and 73% within the first year. There is no reason to suppose that the age at transfer is otherwise for the 3080 cases in which this information is not known.

Experience with samples from the register suggests that most ADs who are not adopted immediately after birth have spent the intervening interval

Table III. Intercorrelations of ADs and Biological Parents

	AD♂ with			AD♀ with			All ADs with		
	BF	BM	MP	BF	BM	MP	BF	BM	MP
Total									
<i>r</i>	0.188 ^a	0.159 ^a	0.215 ^a	0.147 ^a	0.121 ^a	0.139 ^a	0.171 ^a	0.144 ^a	0.184 ^a
<i>N</i>	4699	2319	1912	2914	1451	1183	7613	3770	3015
For ADs with AF = 0									
<i>r</i>	0.124 ^a	0.121 ^b	0.175 ^a	0.101 ^b	0.073	0.136	0.115 ^a	0.105 ^b	0.163 ^a
<i>N</i>	695	336	264	405	205	169	1100	541	433
AF = 1									
<i>r</i>	0.204 ^a	0.079	0.195 ^a	0.150 ^b	0.126	0.202 ^b	0.186 ^a	0.097 ^b	0.202 ^a
<i>N</i>	552	278	224	279	137	107	831	415	331
AF = 2									
<i>r</i>	0.167 ^a	0.188 ^a	0.224 ^a	0.135 ^a	0.073	0.102	0.157 ^a	0.150 ^a	0.183 ^a
<i>N</i>	1076	534	443	659	320	263	1735	854	706
AF = 3									
<i>r</i>	0.162 ^a	0.089	0.107	0.121 ^b	0.202 ^a	0.163 ^b	0.146 ^a	0.130 ^a	0.124 ^b
<i>N</i>	551	264	228	347	179	146	898	443	374
AF = 4									
<i>r</i>	0.154 ^a	0.119 ^a	0.194 ^a	0.103 ^a	0.087	0.043	0.134 ^a	0.108 ^a	0.146 ^a
<i>N</i>	1253	659	548	721	365	295	1974	1024	843
AF = 5									
<i>r</i>	0.096	0.154	0.066	0.061	0.113	0.044	0.073	0.123	0.029
<i>N</i>	254	117	91	204	100	89	458	217	180
AF = 6 and 7									
<i>r</i>	0.222 ^a	0.160	0.220 ^b	0.070	-0.116	-0.078	0.159 ^a	0.048	0.105
<i>N</i>	204	90	82	164	89	73	368	179	155

^a *p* < 0.01.

^b *p* < 0.05.

Table IV. Intercorrelations of ADs and AFs

	AD♂		AD♀		All ADs	
	<i>N</i>	<i>r</i>	<i>N</i>	<i>r</i>	<i>N</i>	<i>r</i>
Total (including unavailable BF)	5736	0.221 ^a	3461	0.193 ^a	9197	0.208 ^a
For ADs with BF = 0	1306	0.212 ^a	761	0.199 ^a	2067	0.207 ^a
BF = 1	490	0.141 ^a	276	0.237 ^a	766	0.170 ^a
BF = 2	1502	0.174 ^a	939	0.136 ^a	2441	0.158 ^a
BF = 3	480	0.191 ^a	322	0.125 ^b	802	0.163 ^a
BF = 4	633	0.238 ^a	354	0.144 ^a	987	0.197 ^a
BF = 5	103	0.302 ^a	78	0.076	181	0.197 ^a
BF = 6 and 7	71	0.184	49	0.345 ^b	120	0.220 ^b
BF not available	1151	0.248 ^a	682	0.227 ^a	1833	0.240 ^a

^a *p* < 0.01.

^b *p* < 0.05.

Table V. Age of ADs at Transfer to Adoptive Homes

Age (in months)	<i>N</i>	Percent
<1	2866	25.3
2	1152	10.2
3	833	7.3
4-6	1610	14.2
7-9	1152	10.1
10-12	693	6.1
13-24	1560	13.7
25-60	1202	10.6
>60	279	2.5
Not available	3080	

in institutions. Nonetheless, since the possibility cannot be excluded that some of this time might have been spent with BPs, it is clearly of interest to examine the intercorrelations for the 2866 ADs adopted within the first month of life, and for whom contact with BPs must therefore have been minimal. These correlations appear in Table VI.

Although the SES-age correlations obtained in this sample are fairly low, it would be wise to heed the caution by DeFries and Plomin (1978) against attaching too much weight to the SES of very young parents. Intuitively it seems reasonable to suppose that there would be a greater degree of "jockeying for position" in the early years of gainful employment and it is certainly characteristically a time of more frequent changes of occupation, leading possibly to erratic shifts of SES.

The data presented here for the BPs are burdened with this difficulty, especially for the BMs, whose average age is precisely 24 years. Correlations are therefore calculated (see Table VII) for those BPs over the age of 25. For the BFs, fathers under 26 years of age were deleted irrespective of

Table VI. Intercorrelations for ADs Transferred Within First Month

	AD♂		AD♀		All ADs	
	<i>N</i>	<i>r</i>	<i>N</i>	<i>r</i>	<i>N</i>	<i>r</i>
BF	966	0.158 ^a	697	0.142 ^a	1633	0.152 ^a
BM	467	0.193 ^a	355	0.144 ^a	822	0.177 ^a
MP	398	0.227 ^a	301	0.132 ^b	699	0.190 ^a
AF	1137	0.218 ^a	811	0.170 ^a	1948	0.197 ^a

^a $p < 0.01$.^b $p < 0.05$.

Table VII. AD-BP Intercorrelations for BPs Over 25 Years of Age

	AD♂		AD♀		All ADs	
	<i>N</i>	<i>r</i>	<i>N</i>	<i>r</i>	<i>N</i>	<i>r</i>
BF	2467	0.195 ^a	1519	0.144 ^a	3986	0.174 ^a
BM	505	0.260 ^a	326	0.159 ^a	831	0.222 ^a
MP	388	0.297 ^a	242	0.121	630	0.231 ^a

^a *p* < 0.01.

mothers' age; the converse was true for the BMs. By comparison with the first row of Table III it can be seen that the AD-BM correlations are indeed increased by this correction.

A plausible hypothesis to explain the AD-AF correlations, at least in part, is that AD has tended to enter the same trade or profession as his or her AF, or has perhaps inherited AF's business, and has thereby obtained the same SES score. While the number of different occupations is too great to permit examination of all types of employment, a representative few of the more common ones are shown in Table VIII. In each case the table includes all pairs where an occupation was available for both AD and AF

Table VIII. AD-AF Relationships for Specific Occupations

Plumber (SES = 2 or 4)			Farmer (SES = 4)		
AF is	AD is		AF is	AD is	
	plumber	other		farmer	other
	plumber	other		farmer	other
	10	60		59	508
other	159	8968	other	48	8582
$\chi^2 = 60.6$			$\chi^2 = 448.9$		
Teacher (SES = 5)			Doctor (SES = 6)		
AF is	AD is		AF is	AD is	
	teacher	other		doctor	other
	teacher	other		doctor	other
	14	306		4	30
other	74	8803	other	49	9114
$\chi^2 = 40.9$			$\chi^2 = 74.6$		

($N = 9197$). Although the number of concordances is never high, the χ^2 test is significant in every case. Thus it can be seen that 4.4% of the adopted children of teachers themselves become teachers (achieving SES class 5) while only 0.8% of the adopted children of nonteachers do so. No such relationship could be observed between AD and BF for any of the occupational titles inspected.

DISCUSSION

The results presented here would appear to allow the following general conclusions to be drawn:

1. The SES of adoptees correlates, persistently but weakly, with that of both the adoptive and the biological parents.
2. Both of these sets of relationships can be observed in subsamples in which the influence of the other is limited (see Tables III and IV). This suggests that selective placement cannot account for any substantial proportion of either relationship.
3. Correlations between adoptees and biological parents are not necessarily mediated by postnatal environmental influences prior to separation. The correlations for adoptees transferred immediately after birth (Table VI) are not systematically lower than the corresponding figures for the entire sample (first row of Table III).
4. The two sets of relationships may well come about in different ways. It has been shown (see Table VIII) that the adoptees have a tendency to "follow in father's footsteps"—in their case, the adoptive father. On the other hand, the relationship with the biological parents must result from less specific mechanisms. There is no evidence of genes for becoming a plumber.
5. The relationships are weaker for female than for male adoptees. This presumably indicates that, in part, and for this generation, a woman's choice of career is less determined by her general or specific abilities than is a man's.

The modest size of the correlations throughout must raise some doubt about the SES scale itself. How good can a scale be which is based solely on occupational title as communicated to official bodies? While it is readily admitted that the scale is a rather blunt instrument, there is reason to believe that it is better than one might otherwise suppose.

First of all, occupational title itself has a considerable formal status in Denmark, a situation which an elaborate system of trades unions and professional organizations does much to encourage. Furthermore, title is in many contexts incorporated into personal identification along with names.

This is indeed quite advantageous in a country with remarkably little variance for surnames. Population statistics record that 69% of surnames end in the letters "sen" (e.g., Jensen, Nielsen, Larsen) and the 15 most common names are shared by over 50% of the population. Until as recently as 1972 occupational title was used as the second sorting criterion, after surname, in telephone directories. Thus to find any given "Petersen" in the directory it was more useful to know his or her occupation than first name.

Within the adoption sample itself, there are regrettably few other data available to validate the scale. The SES of AFs does, however, correlate 0.44 ($N = 12,780$) with their annual incomes when the latter are corrected for inflation during the period 1924–1947.

Some impression of the scale's predictive value regarding intelligence can, fortunately, be derived from another large study which used the same scale and which also obtained intelligence measures. As a part of a project aimed at locating XYY males in a general population, Witkin *et al.* (1976) collected data on a total of 4591 males above 184 cm tall and born in Copenhagen between the years 1944 and 1947. For 4003 of these subjects there are available both an SES score, based on occupation as of 1972, and an Army Draft Board Intelligence Test score. This latter is a paper-and-pencil test, the "Børge Prien Prøve" (BPP) (see Rasch, 1960), comprising four subtests covering both verbal and nonverbal abilities. For the sample used by Witkin, the correlation between SES and BPP is 0.59 ($N = 4003$ $p < 0.01$).

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Social Class Correlations Among Separately Adopted Siblings and Unrelated Individuals Adopted Together

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Small positive correlations for social class ratings are reported for separately adopted full siblings and for unrelated individuals adopted together. No such correlations were found for separately adopted maternal or paternal half-siblings.

KEY WORDS: social class; SES; adoptees; siblings; inheritance.

INTRODUCTION

Separately adopted siblings are a rarity in the literature of human behavior genetics. In a review, Kamin (1974) discusses three studies reporting on IQ correlations, and more recently Schiff *et al.* (1978) compared the IQs of adoptees with those of their nonadopted siblings.

The infrequency of these studies is to be attributed to the difficulty of obtaining samples of such individuals, since they are of obvious value in elucidating genetic components of human behavioral variance.

In addition to the usual advantages of studying genetically related individuals who have had minimal or no contact with each other (e.g., biological mothers and their adopted-away children), there are some advantages specific to the study of siblings. Principally, the use of siblings avoids difficulties which may arise from comparisons across generations, a point emphasized by Munsinger (1975). Where both full siblings and

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half-siblings are available, it becomes possible to compare similarities at two levels of relationship, this constituting a more precise test of a genetic model. The distinction between maternal and paternal half-siblings is also of interest. Both share, on average, 25% of their genetic endowment but the former have also shared the same prenatal environment, at least to the extent that the mother has continued to provide successive offspring with the same uterine conditions. If such conditions were an important determinant of the subsequent behavioral characteristics of the offspring, then one would predict a greater similarity between maternal than between paternal half-siblings.

The Copenhagen Adoption Register, compiled by Kety and co-workers (see Kety *et al.*, 1968) has afforded us an opportunity to locate both full and half-siblings within a large sample of adoptees. It has also been possible to find individuals who, although unrelated genetically, have been adopted and reared together.

For most of these adoptees a rating of social class is available, and this paper investigates the degree of similarity on this measure within these various categories of siblings.

METHOD

The Pedigrees

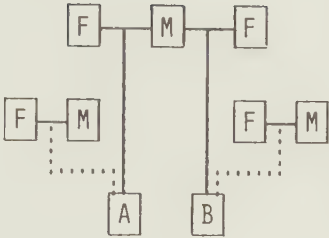
An earlier publication (Teasdale, 1979) reported parent/offspring correlations of social class (SES) derived from a register of the 14,427 non-familial adoptions recorded in Denmark between the years 1924 and 1947 inclusive. In order to locate any siblings among the adoptees a search of this register was made to identify both biological mothers and biological fathers who had adopted away more than one child. Simultaneously a search was made for adoptive parents who had adopted more than one child.

These parallel searches established that 2948 of the 14,427 adoptees were related to some other adoptee (among the 2948) by virtue of common genetic and/or adoptive parentage. These relationships could be grouped into 1319 independent pedigrees comprising between two and eight adoptees. For purposes of illustration, Fig. 1 gives hypothetical examples of pedigrees containing sibships of size two—these being the most common ($N = 1087$)—and of five. Pedigree 1 shows that adoptees A and B have the same biological mother but different biological fathers and are thereby maternal half-siblings; they have, furthermore, been adopted into separate homes. In pedigree 2 adoptee V is a paternal half-sibling to both W and X, who themselves are full siblings. X, however, was adopted by the

Biological
Parental
Generation

Adoptive
Parental
Generation

Sibship
Generation

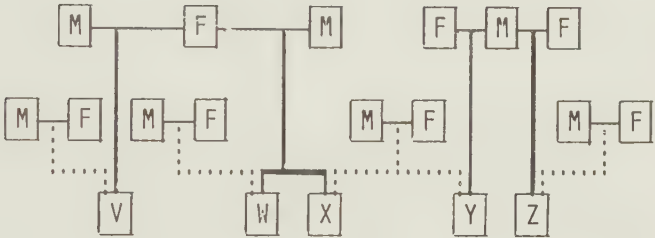


Pedigree 1

Biological
Parental
Generation

Adoptive
Parental
Generation

Sibship
Generation



Pedigree 2

Fig. 1. Hypothetical examples of sibship pedigrees.

same parents as Y, to whom X is unrelated genetically, but Y is a maternal half-sibling to Z.

Considering first genetic relationships, it was found that any two adoptees in a given pedigree could be categorized as one of the following:

- (1) twins,
- (2) full siblings (excluding twins),
- (3) maternal half-siblings,
- (4) paternal half-siblings,
- (5) maternal siblings where paternity was not recorded in one or both cases (the biological father was unnamed for 1252 of the 14,427 adoptees), and
- (6) unrelated.

Concurrently, however, the same two adoptees were adopted either into the same home or into different homes. Taken together, this yields in all $6 \times 2 = 12$ possible relationships. The present study reports only 4 of these:

- separately adopted full siblings (SF),
- separately adopted maternal half-siblings (SM),

separately adopted paternal half-siblings (SP), and genetically unrelated individuals adopted together (TU).

The remaining categories occur very much less frequently, and with the exception of separately adopted twins—of whom there are only 15 pairs, 8 of unlike sex—they are of much less theoretical interest.

The SES Scale

The dependent variable in this study is the social class attained by the adoptee as an adult. For 1953 of the 2948 adoptees an officially registered occupation title (e.g., bus driver, shop assistant) was available. This title was obtained in 1978, at which time their average age was 39 years, the range being from 31 to 67 years. The occupations were rated according to a scale of SES based on a Danish study by Svalastoga (1959). Details of the scale have been published elsewhere (Teasdale, 1979), but it is worth noting here that the scale lays a heavy emphasis on education and training—e.g., university degrees, apprenticeships—typically completed before commencement of employment. The values on the scale extend from 0 = low (e.g., unskilled manual worker) to 7 = high (e.g., university professor). Most of the 995 adoptees who could not be rated with respect to SES were women found in 1978 to be registered as “housewife.”

Statistical Analysis

The appropriate statistical parameter for quantifying the degree of similarity within sets of siblings is the intraclass correlation, defined as

$$\rho = \frac{\sigma_{\text{set}}^2}{\sigma_{\text{set}}^2 + \sigma_{\epsilon}^2}, \quad (1)$$

in which σ_{set}^2 is the variance between sets of siblings and σ_{ϵ}^2 is the pooled within-set variance in a conventional random-effects analysis of variance (see, e.g., Winer, 1971, pp. 248–249). If all pedigree sets were of identical size n , then an unbiased estimate of the intraclass correlation would be

$$\hat{\rho} = \frac{MS_{\text{set}} - c \cdot MS_{\epsilon}}{MS_{\text{set}} + c(n - 1)MS_{\epsilon}}, \quad (2)$$

where $c = df_{\epsilon}/(df_{\epsilon} - 2)$. The $H_0: \rho = 0$ can be tested by the conventional $F = MS_{\text{set}}/MS_{\epsilon}$ with the appropriate df. A difficulty with the formula in

Eq. (2), which uses sample means squares, is the possibility of a negative $\hat{\rho}$, although by the definition in Eq. (1), $\rho \geq 0$. For any $\hat{\rho} < 0$ by Eq. (2), we will take $\hat{\rho} = 0$ to be the best estimate.

Another difficulty, in naturalistic data such as we have, is that the sibships are not of equal size n . One approach to estimating ρ might be to substitute the harmonic mean cell size $\bar{n}$ in the above Eq. (2), obtaining an approximate solution. An alternative procedure for unequal cell sizes, although computationally much more laborious, would be to obtain the maximum-likelihood estimates of the variance components σ^2_{set} and σ^2_{ϵ} and substitute these estimates for the parameters in Eq. (1).

For all social class data, we have computed the conventional least-squares analysis of variance, and we have also estimated the variance components using the BMDP3V maximum-likelihood procedure (Jennrich and Sampson, 1977). Both intraclass correlation estimates are given for comparison.

In order to calculate $\hat{\rho}$ for each of the four sibling categories SF, SM, SP, and TU in turn, the 1319 pedigrees were examined to extract sets, if any, of adoptees bearing the appropriate relationship to each other. Thus, assuming the availability of an SES score for all adoptees in Fig. 1, A and B from pedigree 1 enter the SM computations as one set, as also do Y and Z from pedigree 2. No individual was allowed to appear more than once within the same sibling category correlation since this would artificially deflate the between-sets variance, MS_{set} . Therefore a random choice was made between selecting V and W or V and X from pedigree 2 in calculating $\hat{\rho}$ for SP and in all similar cases. In the few cases where sets of three or more siblings could be formed within one pedigree, these were used. In cases where more than one set of the same relationship category could be formed within the same pedigree, all sets were used, provided that no member of any one of the sets bore any relationship, genetic or adoptive, to any member of any other set. When this was not the case, a random choice was made between the sets. In practice there were never more than two such sets within any pedigree, and these seldom occurred. The application of these rules, which were incorporated into a purpose-written computer program, ensured the maximum utilization of the available data while preserving the independence of the sets employed.

It should be observed that although no adoptee could enter more than once in the same correlation, the same adoptee could appear in more than one correlation. Thus in Fig. 1, pedigree 2, adoptee X is included in the $\hat{\rho}$ for SF together with W, $\hat{\rho}$ for TU together with Y, and might, with a probability of 0.5, be included in the $\hat{\rho}$ for SP with V.

RESULTS AND DISCUSSION

Table I shows, for each of the four relationship categories, the number of sibling sets in which an SES rating was available for all members of every set. It will be noticed that the half-sibling relationship is more common than that of full sibling. This is a reflection of the special nature of the sample. Illegitimacy was by far the most usual ground for giving up a child for adoption, and the biological parents were rarely married partners.

Also shown in Table I are the compositions by sex of the two member sibling sets, from which it can be seen that although the three genetic relationships all have similar distributions [$\chi^2(4) = 1.826$, $P > 0.76$], the TU category is predominantly composed of pairs of unlike sex. Adoptive parents, having a choice in the matter, tended to opt for one child of each sex.

Distributions of SES for the adoptees included in the sets are seen in Table II. There are no adoptees of social class = 7. A χ^2 test indicates significant differences in the distributions of the four relationships [$\chi^2(18) = 32.86$, $P < 0.02$]. Inspection reveals that this results from individuals in the TU category attaining a higher SES than those in the three genetic categories, probably because parents adopting more than one child are themselves above the general average SES of adoptive parents. The distributions for the three genetic categories do not differ significantly among themselves [$\chi^2(12) = 12.03$, $P > 0.44$].

Table III presents the intraclass correlations and corresponding analyses of variance of adoptee adult social class for each of the four relationship categories. The correlations for SF and for TU (estimated, respectively, as 0.2192 and 0.1332 by the maximum-likelihood solution) are both significant. The SF correlation is somewhat larger than the biological father/adoptee correlation ($r = 0.171$) obtained in our original study.

The correlation of TU is, in contrast, lower than was expected on the basis of adoptive father/adoptee correlation ($r = 0.208$) in the original

Table I. Distribution of Pedigree Set Sizes

Relationship	Number of siblings in set			Number of sets	Number of individuals	Sex distribution of size = 2 sets		
	2	3	4			FF	MF	MM
Separate full	98	0	1	99	200	12	47	39
Separate maternal	173	10	0	183	376	20	90	63
Separate paternal	131	5	0	136	277	21	62	48
Together unrelated	254	1	0	255	511	21	194	39

Table II. Distribution of SES in Relationship Categories

Relationship	Social class							Total	Mean SES
	0	1	2	3	4	5	6		
Separate full	24	28	51	53	27	9	8	200	2.45
Separate maternal	44	42	88	109	51	32	10	376	2.58
Separate paternal	26	28	71	96	29	16	11	277	2.60
Together unrelated	56	48	106	129	88	54	30	511	2.84

study. One possible reason for this could be the considerable discordance noted above for sex in the TU sets. It would seem plausible to hypothesize that same-sex siblings would come to resemble each other more, perhaps as a result of modeling behavior during childhood and adolescence, than would unlike sex siblings. The intraclass correlation was therefore recalculated for the TU category using only same-sex sets, then only opposite-sex pairs. For all female sets the maximum-likelihood correlation obtained was 0.3647 [$F(20,21) = 2.37, P = 0.0278$]; for all male sets, 0.3058 [$F(39,40) = 1.98, P = 0.0171$]; and for opposite sex pairs, 0.0648 [$F(194,195) = 1.14, P = 0.1739$].

Although the correlations for the three genetic categories are consistent with a hypothesis of a modest genetic contribution to SES, there are four considerations which should be noted before concluding that such a contribution has been demonstrated here.

First, it might seem dubious to combine the two sexes in analyses of social class given that, in most Western societies, males continue to occupy, on average, relatively higher social status positions than females. Perhaps as a reflection of Danish social organization, there are no substantial differences in either means or variances of SES for the two sexes in these data. In the earlier publication, 5888 male adoptees had a mean SES of 2.72 and SD of 1.63. The corresponding values for 3643 females were 2.55 and 1.47 (Teasdale, 1979).

Furthermore, as noted above, the sex distribution for the three genetic relationships (see Table I) do not differ from each other [$\chi^2(4) = 1.826, P > 0.76$].

These considerations notwithstanding, the analysis might be designed as a two-way analysis of variance with sex included as a fixed factor along with the previously included random factor for sibship set. The unequal n 's seem to prevent a legitimate least-squares solution for this mixed model. However, the maximum-likelihood solution was obtained, producing $\hat{\rho} = 0.2347$, which is very near out value of 0.2192 in Table III, obtained without including sex as a factor.

Table III. Social Class Intraclass Correlations and Analysis of Variance

Relationship	Maximum-likelihood ANOVA			Conventional random-effects ANOVA						
	$\hat{\sigma}^2_{set}$	$\hat{\sigma}^2_{\epsilon}$	$\hat{\rho}$	MS _{set}	df _{set}	MS _e	df _e	F	P	$\hat{\rho}$
Adoptee adult social class										
Separate full	0.4976	1.7723	0.2192	2.8087	98	1.7649	101	1.59	0.0065	0.2179
Separate maternal	0.0	2.3026	0.0	2.1599	182	2.3869	193	0.90	0.7521	0.0
Separate paternal	0.0	2.0413	0.0	1.7804	135	2.1430	141	0.83	0.8608	0.0
Together unrelated	0.3550	2.3097	0.1332	2.9972	254	2.3340	256	1.28	0.0231	0.1204
Adoptive father's social class (selective placement)										
Separate full	0.2533	2.7156	0.0853	3.2559	182	2.7219	199	1.20	0.1082	0.0822
Separate maternal	0.2068	2.3684	0.0803	2.8824	352	2.3459	371	1.23	0.0251	0.0985
Separate paternal	0.3091	2.4652	0.1114	3.2234	249	2.4104	265	1.34	0.0100	0.1383
Adoptee adult social class (early transfers only)										
Separate full	1.0395	1.6071	0.3928	3.8228	27	1.6071	28	2.38	0.0130	0.4080
Separate maternal	0.0	2.0583	0.0	2.0185	59	2.2083	60	0.91	0.6347	0.0
Separate paternal	0.0	1.5574	0.0	1.4943	56	1.8534	58	0.81	0.7892	0.0

Second is the ubiquitous issue of selective placement, i.e., the extent to which adoptive agencies attempt to match the characteristics of the biological and adoptive parents (Ho *et al.*, 1979). If agencies placed children in different social class homes as a function of the SES of their biological parents, then any subsequent correlation between the child and any parent, biological or adoptive, could not be unequivocally attributed to either genetic or environmental contributions. It is another of the advantages of using siblings, rather than parent/child relationships, that the influence of any selective placement is diminished in that the adoptive agency would have to perform the same matching for each successive sibling in order to confound otherwise separated genetic and environmental influences. Nonetheless, any deliberate attempt at matching on the part of the agencies could, if based on characteristics of *both* biological parents, have resulted in a greater similarity of adoptive homes for full siblings than for half-siblings.

In order, therefore, to examine whether the greater SES correlation for full siblings could have been the result of a greater degree of selective placement, $\hat{\rho}$ was computed for the SES of the adoptive fathers for SF, SM, and SP. These results are also shown in Table III. Many more sets are utilized in these calculations than for the SES of adoptee since the SES of the adoptive father is almost always available. The correlations for SM and SP are both significant while that for SF is not, and the maximum-likelihood correlation for SF is not numerically the largest of the three. This means that the separate adoptive homes into which the full siblings were placed do not appear to have been more similar than the separate adoptive homes of the half-siblings.

A third consideration is that the SF siblings are more similar to each other in year of birth than are SM or SP siblings. The intraclass correlations for the three genetic categories, based on all available observations, are 0.8702 (for SF), 0.6951 (for SM), and 0.5266 (for SP). That $\hat{\rho}$ is very high, for each category is a simple consequence of the 36-year age range of the adoptees as a whole, this span being substantially larger than the number of years during which most adults reproduce, and few siblings therefore differ in age by more than 10 years. That $\hat{\rho}$ is greater for full siblings than for half-siblings is also unsurprising. The biological parents have tended to reproduce successively with the same partners at shorter intervals than with different partners. This difference, however, could have an important effect on the SES correlations. As Kamin (1974) observes, identical (or similar) ages of genetically related individuals can lead to spurious correlations when such individuals are measured on a scale sensitive to age. Thus, in the present context, if the SES were highly correlated with age, then the full siblings, as a result of their more similar

ages, would also have a higher SES correlation, albeit in an entirely artificial manner. The SES scale used in this study, however, is not correlated with age. Using all of the 1953 available SES ratings, the linear correlation with age is 0.002, and polynomials through degree 4 are not significant, the multiple correlation being 0.04.

The fourth consideration, like the third, arises from a special feature of full siblings compared to half-siblings. The possibility cannot be dismissed that the former spent a longer time with their biological parents prior to adoption. Although it is not usually known at what age these adoptees were separated from their biological parents, the age at which they were transferred to their adoptive parents is recorded in most cases (2337 of 2948). Table IV lists the age at transfer for all individuals in each of the three genetic categories. Transfer occurred significantly later for SF. Some proportion of these full siblings is known to have come from biological families which broke up as a result of divorce or the death of a parent, but which until that time had provided an intact home environment. It might therefore be the case that the greater similarity of full siblings comes about because of this longer contact with the biological parents.

This, however, could arise only where all the full siblings in any one set have been exposed to an extended contact of this nature. It would not arise where, say, one sibling was transferred to an adoptive home immediately after birth and another sibling was transferred at a later age (or indeed not adopted at all). The SES intraclass correlation was therefore recalculated for SF, SM, and SP, but now including only sets in which all adoptees, or all adoptees except one, were transferred to their adoptive homes within the first month. Table III also presents these correlations of which SF alone is significant, being actually larger numerically than the original values.

Table IV. Age at Transfer to Adoptive Parents

Month	SF		SM		SP	
	<i>f</i>	cum %	<i>f</i>	cum %	<i>f</i>	cum %
1	79	19.8	150	20.8	150	27.9
2	24	25.8	62	29.4	55	38.2
3	26	32.3	63	38.1	37	45.1
4-6	56	46.4	115	54.0	77	59.4
6-12	67	63.2	133	72.0	97	77.5
13-24	63	79.0	107	87.0	54	87.5
25-36	35	87.7	50	94.2	33	93.7
37-156	49	100.0	42	100.0	34	100.0

The absence of a positive correlation for the maternal half-siblings fails to support any hypothesis of intrauterine environment as a factor influencing attained social class. It suggests, furthermore, that the observed correlation for full siblings is not being mediated by such prenatal influences.

There is, however, an inconsistency between the obtained correlations for the full siblings and those for the half-siblings. A simple genetic model would have predicted the former to be approximately twice the latter, in keeping with their respective degrees of average genetic relationship, but this is not the case in the present results. A partial explanation of this anomaly is perhaps the extent of assortative mating among the parents. Plomin *et al.* (1977) reported that social class correlations of biological parents of adoptees varied as a function of their marital status. Unmarried parents correlated less with respect to social class ($r = 0.15$) than did married parents ($r = 0.25$). A higher parental correlation for an at least partially heritable characteristic will lead to a greater correlation between siblings since their common genetic endowment is thereby above the level expected on the basis of random mating amongst parents. For the SF individuals entering Table I, 49% (98/200) were the offspring of biological parents who were married, whereas this was the case for only 14% (52/376) of SM and 16% (43/277) of SP. This suggests that the common genetic endowment of the full siblings has been elevated above its 50% level to a greater extent than that of the half-siblings has been elevated above its 25% level. A more extreme full siblings-half-siblings discrepancy of intraclass correlations than the simple ratio of two to one was therefore to have been expected.

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SOCIAL CLASS AND MOBILITY IN MALE ADOPTEES AND NON-ADOPTES

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Summary. Four hundred and fourteen adoptees were located in a population of 28,879 males born within a 4-year period. For all of these males, two social class ratings were obtained, based upon their occupations at age 25–28 and 35–38. A single rating was obtained for their fathers, based upon occupation at the time of birth of the population males. In the case of adoptees, this rating was obtained for both the biological and the adoptive fathers. The adoptees had, at both ages, an average social class not deviating from that of the population at large. Their biological fathers were, however, below average paternal social class and their adoptive fathers were above it. Positive correlations for social class were found between the adoptees, at both ages, and their biological and adoptive fathers. The social class of adoptees is less well predicted by that of their biological and adoptive fathers, even when these are taken jointly, than the social class of sons in the population is predicted by that of their fathers. Evidence from both the group means and the correlations suggests that the adoptees at age 35–38 came to resemble their biological fathers in social class more than they had done at age 25–28.

Introduction

Earlier studies (Teasdale, 1979; Teasdale & Sørensen, 1983) demonstrated that the social class of adoptees correlates moderately with that of both their biological and adoptive parents, suggesting both genetic and familial–environmental contributions to the determination of adult social class. To assess the generality of these effects it is necessary to compare adoptees with non-adoptees, both in terms of the mean and variance of their social class and that of their parents, and in terms of the correlations between parents and offspring.

Such comparisons become all the more pertinent in view of findings in the related field of intelligence. It has been observed by Munsinger (1975) and by Scarr & Weinberg (1979) that correlational studies of adoptees and their parents and studies comparing means of adoptees with non-adoptees (or with IQ norms) have

yielded what may appear to be paradoxical results. The mean IQ of adoptee groups is usually found to be markedly elevated (e.g. Schiff *et al.*, 1978), suggesting a strong effect of the typically superior adoptive environment, and yet correlational studies (Bouchard & McGue, 1981) ordinarily find only weak relationships between adoptees and their adoptive parents.

Changes in social class between parental and offspring generations constitute one form of social mobility. Social class is not, however, necessarily a stable characteristic throughout a lifetime and there also occurs social mobility within the career of an individual. Although it would be of interest to compare such mobility in adoptees with that of non-adoptees, in keeping with an increasing recognition of the importance of longitudinal data in behavioural genetic studies (DeFries & Plomin, 1978), we are unaware of any such study in the literature hitherto.

For the purposes of comparison with adoptees it is a common practice to select non-adoptees matched on some social or relational criteria. It would be more satisfactory to compare a sample of adoptees with the entire population from which they are drawn. This has become possible for us through the availability of data, from a large birth cohort, originally assembled for the purposes of another study. In an investigation of XYY and XXY chromosomal anomalies, Witkin *et al.* (1976) began by defining a precise population group in which these anomalies were to be located. Since both anomalies are phenotypically male the population cohort was also restricted to males. The available data include own and paternal social class and determination of adoptee/non-adoptee status.

Method

The cohort upon which the present study is based comprises the 31,436 males born from January 1st 1944 to December 31st 1947, whose mothers were officially resident in Copenhagen, Denmark, when they gave birth. These individuals were located by checking the archives of the local parishes, which maintain records of births, marriages, and deaths within the municipality. The occupation of the father was typically stated in the parish birth record and, where found, this was noted. The occupation of the mother was only rarely stated and the variable is not used here. During those years most mothers would probably have been housewives.

From the total number of males, 28,879 were subsequently identified in a Central Person Register (CPR), established in 1968 and covering the entire population of Denmark. The remaining 2557 who were not found are principally accounted for by deaths and emigrations prior to 1968. Full details of these attrition cases are reported by Philip *et al.* (1976).

The CPR includes, amongst other demographic data, a self-reported occupation. This is derived from the returns of annual income-tax forms which are sent out to all adults, stating their current recorded occupation, with a request that any change of occupation should be reported. Where tax-returns indicate such changes the entry in the CPR is updated accordingly. Although reporting occupation or change of occupation is not compulsory, Denmark has a long tradition of using occupational titles virtually as a corporate part of the name of an individual.

Furthermore, Friis-Hasché & Michelsen (1979) found an 86% agreement between occupations as recorded in the CPR and those directly reported by individuals in response to personal questionnaires.

The CPR was initially checked in 1972, at which time the age range of the cohort was 25–28 years, and from it the then current occupations were obtained. To obtain present occupations this operation was repeated in 1982, when the age range was 35–38 years.

In order to identify adoptees, the 28,879 males were also checked against a register of all non-familial adoptions granted in the period 1944–47. This register (which also includes adoptions granted as early as 1924) was compiled by Kety *et al.* (1968) for the purposes of aetiological studies of psychopathology. Checking revealed 414 males to have been adopted into non-familial (i.e. genetically unrelated) homes. The adoption records yielded the occupations of both the biological and the adoptive fathers, although information on the former was occasionally lacking. In 375 cases, the age of the child at transfer to the adoptive home was also specified. Of these, 53% were transferred within the first month of life, 83% within the first 9 months, and the latest transfer took place at the age of 30 months.

Apart from some missing cases, therefore, officially recorded occupations were thus available for five groups of individuals: the 414 adoptees together with their biological and their adoptive fathers, and the remaining 28,465 non-adoptees with what we shall call their 'natural fathers', by which is meant biological fathers who may be assumed to have reared their sons (in making this assumption it is recognized that this will be untrue for some unknown but presumably small proportion of cases, owing to divorce or early death of the father). All of the paternal occupations were as recorded in the years 1944–47. The filial occupations, for both adoptees and non-adoptees, were as recorded in 1972, and then again in 1982.

These occupations were uniformly rated on a scale of social class derived from an extensive Danish study involving prestige ratings of occupation titles (Svalastoga, 1959). The scale ranges from 0 = low (unskilled manual worker, e.g. cleaner, porter) to 7 = high (advanced professional positions, e.g. university professor, judge). Details of the scale have been described elsewhere (Teasdale, 1979).

Results

Table 1 presents the distribution of social class values for the three paternal groups in 1944–47 and for the adoptees and non-adoptees as measured in 1972 and 1982. Variation in the total number of observations in each group is due to unrecorded or unscorable occupations.

The mean social class for the adoptive fathers is significantly higher than for the natural fathers ($t(27512) = 6.14$, $P < 0.001$), probably as a result of both self-selection and selection on the part of the adoption agencies. The opposite is true of the biological fathers, their mean social class being significantly lower than that of the natural fathers ($t(27412) = 6.03$, $P < 0.001$). The mean for the natural

Table 1. Distribution of social class

		Social class							Mean	SD
		0	1	2	3	4	5	6 + 7		
Natural father	<i>N</i>	5536	2314	9195	3837	3858	1212	1152	2.24	1.63
	%	20.4	8.5	33.9	14.2	14.2	4.5	4.2		
Non-adoptee										
	1972									
	<i>N</i>	2392	1670	10,456	5053	2754	1110	2825	2.71	1.62
	%	9.1	6.4	39.8	19.2	10.5	4.2	10.8		
	1982									
	<i>N</i>	2122	1866	8198	4780	3633	3013	3166	3.03	1.72
	%	7.9	7.0	30.6	17.8	13.6	11.3	11.8		
Biological father	<i>N</i>	89	35	124	24	28	7	3	1.68	1.40
	%	28.7	11.3	40.0	7.7	9.0	2.3	1.0		
Adoptive father	<i>N</i>	56	46	92	49	116	27	24	2.73	1.71
	%	13.7	11.2	22.4	12.0	28.3	6.6	5.8		
Adoptee										
	1972									
	<i>N</i>	33	20	160	80	56	23	19	2.64	1.44
	%	8.4	5.1	40.9	20.5	14.3	5.9	4.9		
	1982									
	<i>N</i>	35	25	115	71	80	37	26	2.90	1.60
	%	9.0	6.4	29.6	18.2	20.6	9.5	6.7		

fathers lies almost precisely half way between those of the biological and adoptive fathers.

It could be suspected that the differences in mean paternal social classes might be no more than a reflection of age differences between the groups. For reasons related to the design of the original study, age of the natural fathers is available only for the 3833 whose sons were the tallest among the 28,879 cohort. These fathers had a mean age of 31.9 years ($SD = 6.7$) compared to 36.4 years ($SD = 5.7$) for the adoptive fathers and 29.7 years ($SD = 8.1$) for the biological fathers. Evidently, some selection and self-selection with respect to age has also been operating for both the biological and adoptive fathers. If the social class scale were highly correlated with age this might be sufficient to account for the social class differences also, but such does not appear to be the case. For the subsample of 3833 natural fathers the correlation between age and social class is only 0.059.

It is suggested that this weak correlation arises through two opposing factors. Since social class of the fathers is measured during a relatively short interval, 1944–47, then any tendency for a positive age–social class correlation, arising by virtue of promotion and advancement among the older fathers, will be offset by a secular trend towards better education and a greater proportion of skilled occupations in the labour market—a trend which, by benefiting more the younger fathers, would tend to produce a negative age–social class correlation. Evidence of such a secular trend appears in the difference in mean social class between non-adoptees and their natural fathers.

Among the filial groups, it was found that of the 372 adoptees having a scorable

occupation in both 1972 and 1982, the correlation between the two social class values was 0.749, and that 58% of the adoptees had changed occupations during the 10-year interval. For the 25,178 non-adoptees, the correlation between 1972 and 1982 social class was 0.771, and 60% of them had changed occupations. The two groups did not differ significantly in their mean social class in either year, although inspection of the means does suggest that the adoptees are somewhat failing to keep pace with the non-adoptees, the gap between the two groups being rather wider in 1982 than in 1972. Both adoptees and non-adoptees improved their social class significantly across the decade: for adoptees $t(371) = 4.55$, $P < 0.001$ and for non-adoptees $t(25177) = 38.44$, $P < 0.001$. This implies the operation of the promotion and advancement mechanism hypothesized above.

One central question of the present study is whether the adoptees, even if themselves of a mean social class not differing from that of non-adoptees, have attained a higher level than would be expected from them on the basis of their biological fathers being below average social class or a lower level than would be expected on the basis of their above average adoptive fathers. To answer this question four standardized residuals from the linear regression of filial on to paternal values were calculated for the full cohort, i.e. adoptees and non-adoptees combined. These comprised two values for both 1972 and 1982 filial social class in which the paternal values used for the adoptees were respectively those of their biological and adoptive fathers.

The mean of adoptee residuals from the predicted values based upon the adoptive fathers' social class was significantly negative for both years (for 1972 $t(25392) = 3.56$, $P < 0.001$, for 1982 $t(25888) = 3.92$, $P < 0.001$), indicating that the adoptees do attain a lower social class than would be predicted from that of their adopted fathers. Conversely the mean of adoptee residuals from the predicted values based upon the biological fathers' social class was significantly positive for adoptees' social class in 1972 ($t(25298) = 2.38$, $P = 0.017$) but was non-significantly positive for 1982 ($t(25795) = 1.64$, $P = 0.101$). This latter finding again suggests that although adoptees commence their adult careers at levels above those which would be predicted from their biological fathers, their failure to keep pace, across a decade, with the general upward tendency in social class mobility represents a relative decline towards levels corresponding to those of the biological fathers.

The variance for the social class of the adoptive fathers is slightly but non-significantly greater than that of the natural fathers ($F_{\max}(409,27103) = 1.10$, $P = 0.131$). This indicates that the adoptees were not reared in a narrower range of environments than are found in the general population. Conversely, however, the variance for the social class of the biological fathers is significantly smaller than that for the natural fathers ($F_{\max}(309,27103) = 1.35$, $P < 0.001$), which might imply that the genetic variance transmitted to the adoptees is less than that of the general population. This interpretation is consistent with the significantly lower social class variance for the adoptees themselves (for age 25–28, $F_{\max}(390,26259) = 1.27$, $P = 0.001$; for age 35–38, $F_{\max}(388,26777) = 1.15$, $P = 0.064$), although, as discussed below, there might be other reasons for the restricted variance among the adoptees.

Table 2. Social class correlations between fathers and sons

	1972		1982	
	<i>r</i>	<i>N</i>	<i>r</i>	<i>N</i>
Natural father–non-adoptee	0.394	25,007	0.373	25,505
Biological father–adoptee	0.172	293	0.235	292
Controlling for adoptive father	0.148	290	0.220	289
Adoptive father–adoptee	0.190	387	0.168	385
Controlling for biological father	0.161	290	0.120	289

The correlations of social class between the fathers and sons are shown in Table 2; all correlations are significant ($P < 0.05$). In both 1972 and 1982 the correlation between non-adoptees and their natural fathers was significantly higher than those for the adoptees with either their biological or adoptive fathers.

In order to compare pairs of correlations sharing a common variable (e.g. natural fathers with non-adoptees in 1972 and in 1982) a test proposed by Williams (1959) and cited, as T2, by Steiger (1980) has been used. Tested in this way, the reduction in correlation of the non-adoptees with their fathers between 1972 and 1982 was significant ($t(25004) = 5.37$, $P < 0.001$), whereas the corresponding changes of adoptee–biological father and adoptee–adoptive father correlations were not significant. There is nonetheless evidence that the correlation between the biological father and the adoptee has actually increased over the 10-year period. The partial correlation of biological father with adoptee 1982 social class, controlling for that in 1972, is 0.159 ($P < 0.01$). Neither in 1972 nor in 1982 did the adoptee–biological father and adoptee–adoptive father correlations differ significantly from each other.

Adoption agencies often attempt to place children in homes selectively as a function of various characteristics of the biological and adoptive parents (Ho, Plomin & DeFries, 1979). Within the present adoptee sample the social class correlation between the two fathers is 0.168 ($P < 0.01$). This confirms that some degree of selective placement has been practised, which raises a theoretical difficulty in that the subsequent similarity of the adoptee to either the biological or adoptive father could be inflated by the indirect effect of the other father. Obviously a very precise matching would invalidate the study of adoptees as a means of distinguishing the influences of genes and environment. The selective placement correlation obtained here, however, does not encourage the notion that either of the father–adoptee correlations has, to any great extent, come about in such an indirect manner. Table 2 also lists the partial correlations of adoptees with each father controlling for the effect of the other father. In all cases the partial correlations remain significantly greater than zero ($P < 0.05$) and are not significantly lower than the corresponding original non-partialled correlations.

The two forms of paternal contribution, genetic and familial–environmental, to the adoptees' own social class as an adult appear to be approximately equal. One

might then ask whether these two contributions jointly predict that social class to the same extent that the social class of the non-adoptees is predicted by that of their fathers. The answer is that the social class of the adoptees is much less well predicted. The multiple correlation of the adoptees in 1972 with the joint linear contributions of biological and adoptive fathers is 0.237 which remains significantly lower ($z = 2.95$, $P < 0.01$) than the non-adoptive correlation of 0.394. The corresponding multiple correlation for the adoptees' social class in 1982 is 0.264 which similarly remains significantly below the non-adoptive value of 0.373 ($z = 2.04$, $P < 0.05$). The adoptee predictions were not significantly improved by the seven quadratic, cubic, and interaction terms constructed from the biological and adoptive fathers' scores.

Discussion

In contrast to the characteristic finding that adoptees are of above average IQ, the adoptees in our cohort have achieved, as adults, a mean social class slightly but non-significantly below that of non-adoptees. Not surprisingly, the biological fathers proved to be below the average social class of their generation whilst the adoptive fathers were above it. The analyses of regression residuals confirm what these mean levels suggest. First, the social class of adoptees has been boosted above that which is attained by non-adoptees who are reared in the homes of fathers at the same low level as the biological fathers, although this effect reaches significance only in the adoptees' initial 1972 level. A decade later they appear to have lost some of this advantage. Such as it is, the boost is largely to be ascribed to the beneficial effect of being transferred, very early in life, to a comparatively better social class home. Second, this boost nevertheless falls short of bringing the adoptees up to the level which is attained by non-adoptees who are reared in the homes of fathers at the same high level as the adoptive fathers.

That the adoptive fathers should have had a positive overall effect upon the mean social class of the adoptees is entirely consistent with the correlations between adoptive fathers and adoptees at the individual level. Conversely, the correlations between the biological fathers and the adoptees suggest some degree of genetic influence on social class and this is consistent with the adoptees having attained a mean social class lower than that of non-adoptees reared in the same quality of familial environments.

There is a weak tendency for the mean level of adoptees to fall, relative to the non-adoptees, over the 10-year period towards what would be predicted by that of their biological fathers. Furthermore, a partial correlation indicates that social mobility in the adoptees over the time interval, irrespective of their initial level, is also predicted by the social class of the biological father. A plausible hypothesis to account for these two findings would be that some genetic factors, which have lain concealed or dormant while the adoptees were growing up in the adoptive homes, begin gradually to manifest themselves in adult life.

Other findings consistent with this hypothesis have been reported in Teasdale & Sørensen (1983). Among a larger number of male adoptees it was found that the social class of the biological father (and also the adoptive father) retained a

predictive value for the social class of the adult adoptee beyond what was mediated by the adoptee's level of education. This effect was not observed for female adoptees, perhaps because social class and mobility for females have traditionally been somewhat haphazardly determined.

The correlation of the biological father's social class with that of the adoptee may primarily reflect the inheritance of intelligence. Cumulated evidence suggests an important, if not readily quantifiable, degree of heritability for intelligence (Bouchard & McGue, 1981), and intelligence itself, usually operating through educational level, correlates quite highly with adult social class. Combining results from several large scale studies, Jencks (1972) estimates this correlation to be 0.45.

The correlation of the adoptive father's social class with that of the adoptee perhaps reflects the influence of the familial environment on the extent to which the adoptee has the motivation and industriousness to continue a school career, educational level being the strongest predictor yet identified of adult social class (Jencks, 1972).

The father-son correlations observed here for the adoptees are, however, modest and lie significantly below those of natural fathers with non-adopted sons, these being in very close agreement with the value of 0.369 estimated by Jencks (1972), also from several large scale studies. It has not proved possible to construct a combination of the biological and adoptive fathers' social classes in a multiple correlation with adoptee social class which, even when including multiplicative and non-linear terms, approaches those of the non-adoptive relationship.

There would appear to be several ways, not necessarily exclusive of each other, in which this discrepancy could have arisen.

First, it is probable that the degree of genetic communality is somewhat higher between natural fathers and their sons by virtue of the greater degree of assortative mating presumed to have taken place among the parents of the non-adoptees than among the parents of the adoptees, the large majority of whom were illegitimate (Teasdale & Owen, 1981). Plomin, DeFries & Roberts (1977) have reported a lower social class correlation between unwed couples (0.15) than between wed couples (0.25).

A second, related, explanation might be that the genetic variance transmitted by the biological fathers appears to be restricted. As noted by Loehlin (1980) in the context of IQ studies, restriction of genetic variance will lead to an underestimation of the genetic contribution to phenotypic variance.

Third, it is possible that adults have selected for themselves environments which 'suit' their genotypes better than would a randomly selected environment. This environment should, on average, also prove appropriate for the genotypes of their offspring, as a result of the correlation between parent and offspring genotypes. The natural parent's contributions of genotype together with environment could thus act in concert or synergistically. For the adoptees, however, the genetic and environmental contributions are much more nearly randomized and the synergism is lost. If these events hold, then the adoptee social class should indeed be less well predicted from the biological and adoptive fathers jointly than is the non-adoptee social class predicted from the natural father. The smaller variance found for the social class of the adoptees might be indicative of a lack of genotype-environment interaction.

A fourth possibility is that the correlation between adoptive father and son might be weakened because adoptive parents, harbouring a readiness to perceive the emergence of genetically influenced characteristics in the adoptee, might be less directive and more tolerant of a wider range of success and failure in their upbringing of him. This 'de-coupling' effect could be further enhanced by the child's eventual discovery that he is adopted.

Scarr, Scarf & Weinberg (1980) have attempted to explore this possibility by obtaining subjective self ratings from parents and offspring regarding their mutual similarity on a variety of psychological dimensions. The data were obtained from both adoptive and non-adoptive families. Although such similarity ratings were found to be generally lower among members of adoptive families, the ratings were uncorrelated to the degree of similarity as measured by objective tests. From this they conclude that the lower perceived similarity in adoptive families cannot itself be the cause of the lower objectively measured similarity. Such negative evidence is not, however, totally convincing since the subjective rating scale may simply be too insensitive a measure to quantify a history of parent-offspring interaction.

Conversely, however, it seems unlikely that there is any attenuation of the correlation between the adoptive father and the adoptee by restriction of variance in the adoptive fathers' social class, for this variance is, in fact, slightly greater than that of the natural fathers.

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EDUCATIONAL ATTAINMENT AND SOCIAL CLASS IN ADOPTEES: GENETIC AND ENVIRONMENTAL CONTRIBUTIONS

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Summary. The number of years of schooling and adult social class of 1417 adoptees are found to correlate with the social class of both their biological and adoptive fathers. For female adoptees the effect of both paternal social class values upon own social class appears to be mediated through the influence of the former upon years of schooling. For male adoptees, some residual direct correlations of paternal social class with offspring's social class, independent of years of schooling in the adoptee, are observed.

Introduction

That parents' social class continues to be an important determinant of that of their offspring is evident. No less so is the essential role of education in mediating between the social class of two successive generations. Thus parental social class is related to the duration of the education the offspring receives, which, in turn, is a prime influence on the latter's own social class as an adult (Jencks, 1972; Sewell & Hauser, 1975).

It is unclear, however, to what extent, if any, such social transmission from one generation to the next is influenced by genetic factors in addition to the environmental factors which must be involved, these two influences being confounded in the usual nuclear family setting. The difficulty of obtaining empirical evidence which would help to resolve this confounding may have led to the relative dearth of studies specifically assessing genetic effects, a dearth which is surprising in view of the substantial amount of research on educational attainment and social class.

One notable exception is a study by Behrman, Taubman & Wales (1977) which reported a higher correlation of adult social class for MZ twins (0.429) than for DZ twins (0.205). Unfortunately, as Goldberger (1977) commented on Behrman *et al.*'s study, behavioural twin studies are notoriously hampered by uncertainty regarding the degree to which the environments of MZ twins are more similar than are those of DZ twins.

That both schooling and social class are related to intelligence is hardly to be disputed (Herrnstein, 1973), and a sizable genetic component of IQ variability

would imply the importance of such components in education and social class also. The heritability of intelligence has been the subject of extensive research, especially by seeking correlations between adoptees and their biological parents (see reviews by Munsinger, 1975; Loehlin, 1980). Many such adoption studies have, in fact, availed themselves of social class estimates for biological parents in default of direct measures of intelligence. Owing to alleged methodological and other deficiencies in these studies, however, the inheritance of intelligence itself remains vigorously controversial (Eysenck & Kamin, 1981) and its role in the parent-to-offspring transmission of education and social class still at issue.

Earlier evidence, derived from a large adoption cohort, showed modest degrees of both genetic and familial-environmental determination of social class in adoptees (Teasdale, 1979; Teasdale & Owen, 1981). The object of the present report is to demonstrate that these determinants also influence educational attainment and that, as in the case of non-adoptees, most of the transmission of social class from parent to offspring appears to be through educational attainment.

Method

The adoption cohort

The cohort upon which the present study is based comprises the 5455 non-familial adoptions recorded in the municipality of Copenhagen in the period 1924-47. Access to these records, in the archives of the Danish Ministry of Justice, was obtained by Kety *et al.* (1968) for the purposes of aetiological investigations of psychopathology. The records identify, by name and date of birth, all of the five individuals involved, i.e. the biological parents, the adoptive parents and the adoptee, as well as indicating details of the circumstances of the adoption including, for 79% of cases, the age at which the adoptee was transferred to the adoptive home.

Paternal social class and income

The records also indicate the occupation of the biological father, for the 80% of cases where this is known, and of the adoptive father, together with the annual income of the latter. Only one-third of the biological mothers and virtually none of the adoptive mothers had any recorded occupation. The paternal occupations were coded on a scale of social class derived from an extensive Danish study of prestige ratings of occupational titles (Svalastoga, 1959). The scale ranges from 0=low (unskilled manual worker, e.g. cleaner, porter) to 7=high (advanced professional positions, e.g. university professor, judge). Details of the scale have been reported elsewhere (Teasdale, 1979).

Education and social class of adoptee

In 1979-80, as the first phase of a study of the heritability of obesity and thinness (Stunkard, Sørensen & Schulsinger, 1983), a postal questionnaire, principally concerning height, weight and health history was sent to the 4643 adoptees who were alive and resident in Denmark at that time. The remaining 812 who were not contacted comprised 335 who had died, 426 who had emigrated and

51 who could not be identified. Responses were obtained from 3651 (79%) of those who were contacted. The questionnaire included two items concerning education. (1) For how many years did you attend school? (2) Did you ever repeat a grade?

The structure of the Danish educational system did not change in any fundamental way during the 24 years covered by the adoption cohort. Throughout the period schooling was obligatory between the ages of 6 and 13, i.e. a minimum of 7 years, and, depending upon examination success, could be continued up to age 18, i.e. a maximum of 12 years. For the 14% of adoptees who reported repeating a grade, one year was deducted from the number of years schooling they had stated. Thereafter adoptees with less than 7 years' schooling (3%) were recoded to 7 to avoid giving undue weight to what must have been exceptional circumstances. Some adoptees (2%) had taken 13 years to attain the highest level of schooling, usually completed in 12 years. These were recoded to 12, as were the values for those adoptees (1%) who had included further education (university, training college, etc.).

The social class of the adoptees was derived from their occupations, where available (66%), in 1977 at which time they were, on average, 39 years old ($SD=8.2$). These occupations had been obtained from annual income-tax returns and were coded on the social class scale referred to above.

Sample selection

The present report is limited to the 1417 adoptees for whom all of the required data are available and who are known to have been transferred to the adoptive home within the first year of life. Attrition from the initial total of 3651 questionnaire responders is due to biological fathers being unknown (20%), adoptees with no recorded occupation in 1977 (34%, mainly females), and adoptees who were transferred later than one year, or for whom age at transfer is unknown ($21\% + 21\% = 42\%$).

Results

Distributions for the three paternal variables and for the two adoptee variables for each sex, are shown in Table 1. Adoptive father's income proved to have an extremely skewed distribution and a natural log transformation was applied; the transformation is implicit in all subsequent references to this variable. There are sex differences both in years of schooling ($t_{1415}=3.54$, $P<0.001$), female adoptees having attended school for longer, and in social class ($t_{1415}=4.02$, $P<0.001$), male adoptees attaining a higher social class.

Adoptive father's income and social class, as one might expect, are quite highly correlated with each other ($r=0.476$, $P<0.01$) but both of these variables also correlate with the social class of the biological father. The correlation of biological father's social class with adoptive father's income is 0.121 ($P<0.01$) and with adoptive father's social class it is 0.170 ($P<0.01$). These correlations reveal that the adoption agencies practised some degree of selective placement, an important factor in adoption study designs considered in detail by Ho, Plomin & DeFries (1979).

Table 1. Distribution of paternal and adoptee variables

	Scale												Mean	SD	
	0	1	2	3	4	5	6	7	8	9	10	11			12
Adoptive father's income (kr × 1000)*	4	37	163	258	316	188	129	89	233†					5.85	14.03
Social class															
Adoptive father	223	134	390	218	287	97	68	0						2.55	1.67
Biological father	349	141	507	173	174	53	19	1						1.94	1.51
Years of schooling															
Male adoptee								210	160	132	178	24	85	8.88	1.60
Female adoptee								129	101	110	183	28	77	9.18	1.59
Social class															
Male adoptee	56	40	239	165	149	88	51	1						2.99	1.54
Female adoptee	66	47	70	343	58	28	16	0						2.68	1.33

*Because of extreme skewness this variable was log transformed for all analyses.

†Scale 8+ for this factor.

Table 2 shows the correlations of the three paternal variables with the age of the father at the birth of the adoptee and with the year of birth of the adoptee. The correlations with age demonstrate a tendency to increasing income and social class with increasing age, whereas the correlations with adoptee's year of birth indicate secular trends through the 24-year interval (1924–47) spanned by the adoption cohort. The upward tendency of income and social class in the adoptive fathers

Table 2. Correlations of paternal and adoptive variables with paternal age at birth of adoptee and year of birth of adoptee

	Age at birth of adoptee	Year of birth of adoptee
Adoptive father's income	0.119**	0.339**
Social class		
Adoptive father	0.081*	0.111**
Biological father	0.139**	-0.069*
Years of schooling		
Male adoptee		0.195**
Female adoptee		0.194**
Social class		
Male adoptee		0.002
Female adoptee		0.146**

* $P < 0.05$; ** $P < 0.01$

probably reflects the general population trend in Denmark during those years. The decline in the social class of the biological fathers may be attributed to the relatively later widespread use of contraception among lower classes; illegitimacy was by far the most common reason for a child being given up for adoption.

An upward secular trend is also seen in years of schooling (Table 2), to an equal extent for male and female adoptees, and a similar trend appears in social class for females although not for males. Since social class was measured at a fixed date (1977) for the adoptees, an upward secular trend would be counterbalanced by any positive age effect. The positive correlation for females therefore suggests, in their case, that the former factor outweighs the latter.

Whatever the causes of such secular and age trends it is clear that they complicate the interpretation of the parent-offspring correlations which are the focus of the present study. For this reason regression analyses of the paternal social class and income variables on both years of schooling and social class as independent variables were performed holding constant the two paternal ages and the year of birth of the adoptee, assuming both quadratic and linear trends to be present in the effects of these control variables. Given the sex differences noted above it also seemed advisable to perform separate analyses for male ($n = 789$) and female ($n = 628$) adoptees.

Years of schooling

Table 3 shows simple and partial correlations of the paternal variables with years of schooling. The partial correlations are derived from stepwise regression as described above. All of the values in this table are significantly greater than zero

Table 3. Simple and partial correlations of paternal variables with adoptee's years of schooling

	Simple correlation	Partial correlations	
		Controlling for year and paternal age	Also controlling for variable indicated
Male adoptees			
Adoptive father's income (AAI)	0.293**	0.240**	0.224** BSC
Social class			
Adoptive father (ASC)	0.334**	0.310**	0.290** BSC
Biological father (BSC)	0.197**	0.209**	0.171** AAI & ASC
Female adoptees			
Adoptive father's income (AAI)	0.360**	0.313**	0.278** BSC
Social class			
Adoptive father (ASC)	0.323**	0.310**	0.273** BSC
Biological father (BSC)	0.219**	0.230**	0.156** AAI & ASC

** $P < 0.01$.

($P < 0.01$). The effect of the age and year controls is most marked in adoptive father's income, in keeping with the strong secular trend operating for this variable. The effect of the controls to increase marginally the partial correlations for biological father's social class is attributed to the negative secular trend for this variable.

The presence of positive correlations between the adoptive and biological father variables, resulting from selective placement, bears the important consequence that the subsequent correlations between either father and the adoptee could be inflated by the indirect effect of the other father. Table 3 therefore includes partial correlations between the variable(s) for each father and years of schooling, controlling for, in addition to age and year of birth of adoptee, the variable(s) relating to the other father. It is a reflection of the modest degree of selective placement observed that such partialling has only a small effect on the predictive value of all three paternal variables.

None of the partial correlations in Table 3 differs significantly between the sexes. For both sexes there is a discernible tendency for education to be better predicted by adoptive father's income and social class than by biological father's social class, although in only one comparison (social class of adoptive versus biological father for male adoptees) does this reach significance ($0.310 > 0.209$, $z = 2.149$, $P < 0.05$).

Social class of adoptee

Table 4 shows the corresponding simple and partial correlations of the paternal variables with social class. With a single exception the values in this table are significantly greater than zero ($P < 0.05$). None of the partial correlations differs significantly between the sexes. It is also noteworthy that in males and females,

Table 4. Simple and partial correlations of paternal variables with adoptee's social class

		Partial correlations		
	Simple correlation	Controlling for year and paternal age	Also controlling for variable indicated	
Male adoptees				
Adoptive father's income (AAI)	0.122**	0.137**	0.118**	BSC
Social class				
Adoptive father (ASC)	0.249**	0.247**	0.226**	BSC
Biological father (BSC)	0.202**	0.201**	0.172**	AAI & ASC
Female adoptees				
Adoptive father's income (AAI)	0.189**	0.157**	0.135**	BSC
Social class				
Adoptive father (ASC)	0.179**	0.170**	0.147**	BSC
Biological father (BSC)	0.115*	0.122**	0.079	AAI & ASC

* $P < 0.05$; ** $P < 0.01$.

social class is as well predicted by biological father's social class as by adoptive father's social class or annual income.

The correlation within the present sample between years of schooling and social class is 0.529 ($P < 0.01$) for male adoptees and 0.471 ($P < 0.01$) for female adoptees. The question therefore arises to what extent the influence of the paternal variables on social class in the adoptees can be accounted for by their influence on schooling.

Table 5. Partial correlations of paternal variables with adoptee's social class

	Partial correlations		
	Controlling for year, paternal age and adoptee's years of schooling	Also controlling for variable indicated	
Male adoptees			
Adoptive father's income (AAI)	0.010	0.003	BSC
Social class			
Adoptive father (ASC)	0.100**	0.092*	BSC
Biological father (BSC)	0.108**	0.102**	AAI & ASC
Female adoptees			
Adoptive father's income (AAI)	0.018	0.015	BSC
Social class			
Adoptive father (ASC)	0.035	0.032	BSC
Biological father (BSC)	0.021	0.015	AAI & ASC

* $P < 0.05$; ** $P < 0.01$.

Table 5 shows the partial correlations for the three paternal variables with adoptee's social class when, in addition to the usual controls, the effect of years of schooling is also removed. As would be expected from the high correlations between years of schooling and social class, the values in Table 5 are much diminished from the corresponding values in Table 4. None of the partial correlations for female adoptees is significantly greater than zero, nor is that for adoptive father's income in the case of male adoptees. For males, however, a significant residual correlation between social class and both adoptive and biological fathers' social class remains.

Following path analytic conventions (Duncan, 1966; Kim & Kohout, 1975) these relationships are summarized graphically in Fig. 1, using standardized beta values from the regression analyses.

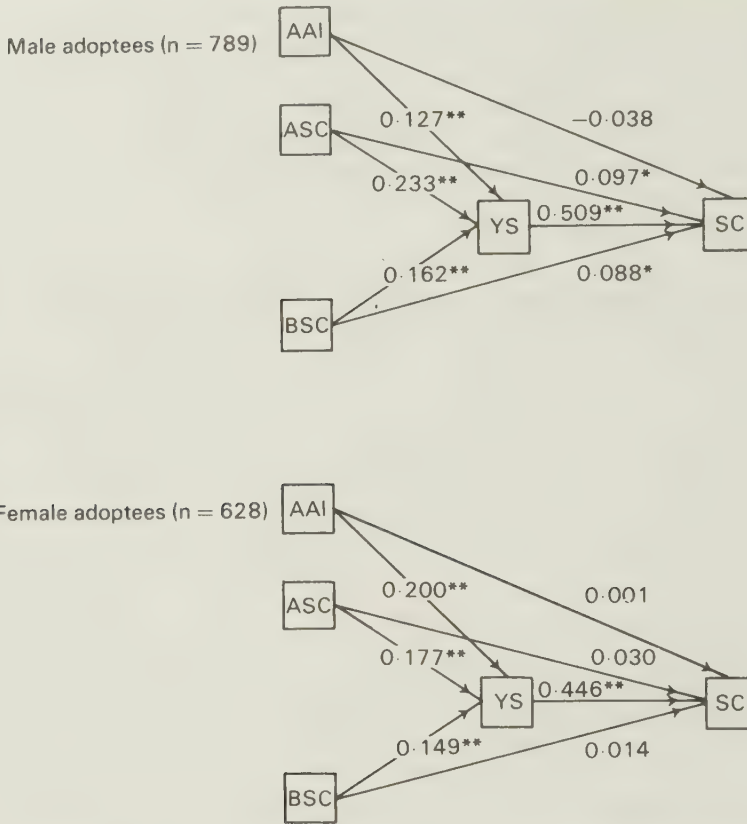


Fig. 1. A path model of the influence of paternal variables (adoptive father's annual income, AAI, and social class of adoptive father, ASC; and of biological father, BSC) on adoptee's years of schooling (YS) and social class (SC); * $P < 0.05$, ** $P < 0.01$.

Discussion

These results suggest that both familial–environmental and genetic factors play a role in determining educational attainment and that such attainment appears to account for much, but not all, of the continuity in the social classes of successive generations.

Considering first the determination of educational attainment, the results for the two sexes are very similar and they may be considered independent replications of the same findings. It is perhaps not surprising that the income and social class of the adoptive father should be important factors since the adoptee, while still at school, is necessarily under the direct influence of his or her adoptive family. Thus a wealthy, high status adoptive home would probably encourage motivation for achievement and provide an environment conducive to good academic performance. Conversely, the adoptee from a poorer home might be pressured to leave school early in order to begin to earn a wage.

Although of apparently lesser magnitude than the contributions of the adoptive father, some contribution of the biological father to the adoptee's educational attainment has been made and this must have occurred through the inheritance of some psychological characteristics. Whilst one can only speculate as to the nature of these characteristics, intelligence inevitably suggests itself as one candidate, although other possibilities include aspects of personality such as goal directedness and level of aspiration.

Both biological and adoptive paternal social classes have no predictive value for the social class of female adoptees beyond the indirect effect mediated through years of schooling. For male adoptees, however, some proportion of the father-son social class correlations is independent of schooling. With respect to the adoptive father, there is a tendency (Teasdale, 1979) for the adoptee to enter the same trade or profession as his adoptive father, or, indeed, directly to inherit a family business. Such continuity from one generation to the next, would result in a father-offspring correlation in social class irrespective of the education of the adoptee.

The residual effect on male adoptee's social class of the social class of the biological father seems to point to a genetic effect appearing in the adult which had not appeared in childhood. This might again be a consequence of the fact that the adult variable for the adoptee is the same as that for the biological father, i.e. social class, or a simple result of imprecision in the measurement of educational attainment.

An alternative explanation can, however, be offered. Unpublished data from another adoptee sample derived from the full adoption cohort show that the correlation between the social class of biological fathers and male adoptees at age 25 is 0.17, but rises to 0.24 when the social class of the same adoptees is re-measured at age 35. This finding, together with those of the present analysis, is consistent with the tentative hypothesis that, as adoptees become more remote from their initial adoptive environments, genetic factors which, in their childhood, lay suppressed or dormant can begin to express themselves. That this should be true for male adoptees but not for females could be due to the historically lower degree of social mobility in the latter.

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Heredity and familial environment in intelligence and educational level—a sibling study

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Although it is well established that family members resemble each other in intelligence¹, the extent to which this results from either shared genes or a shared environment remains controversial², perhaps especially since the relevant evidence presented by Burt has been shown probably to have been fabricated³. The influence of heredity and familial environment may be distinguished by studying adoptees. Here we present correlations in intelligence and educational level between genetically related pairs of adult adoptees who have been reared separately, and, conversely, between genetically unrelated pairs of adult adoptees who have been reared together. We are unaware of any previous study of adults which has reported on both of these types of relationship. The results for intelligence conform closely to what would be predicted by a simple polygenic model of genetic transmission whereas those for educational attainment imply both genetic and familial environmental components.

From a Danish adoption register^{4,5} we have identified four groups of sibling pairs. The first three groups comprise genetically related pairs who were adopted and reared apart in separate families: full siblings reared apart (FA, 34 pairs), maternal half-siblings reared apart (MA, 52 pairs) and paternal half-siblings reared apart (PA, 41 pairs). The fourth group comprises genetically unrelated pairs who were adopted and reared together in the same families (UT, 27 pairs). All of these adoptees were male, born between 1938 and 1947. Their median age at transfer to their adoptive homes was 5 months, and 86% had been transferred by 2 years of age.

Intelligence and education data for these adoptees were obtained from draft board records. Danish conscription law requires males, on attaining the age of 18 (or shortly thereafter, and not later than 26 years old), to appear before a draft board. A medical examination is performed, educational level (EL) is recorded on a 9-point scale from 1 = minimum years of grade school (that is, 7) to 9 = university degree, and an intelligence test, the Børge Prien Prøve (BPP)⁶, is administered.

The BPP is a 45-min group test consisting of four subtests covering broad areas of cognitive functioning: letter matrices (similar to Raven's progressive matrices), verbal analogies, number series, and geometric figure analysis. Each subtest comprises approximately 20 items arranged in order of increasing difficulty. The BPP score is the total number of correct answers.

BPP and EL scores, together with height, were traced in the draft board archives for 28 FA pairs, 34 MA pairs, 30 PA pairs and 24 UT pairs.

We have also identified a fifth group comprising 73 pairs of non-adopted brothers, that is, full siblings reared together by their biological parents (FT). These pairs, for whom height and BPP and EL scores were also available, are derived from a large sample of males used in another study⁷ and differ somewhat from the adoptees. They were born between 1944 and 1947, they were almost all reared in Copenhagen rather than, as were the adoptees, distributed across Denmark, and they were at least 184 cm tall.

Quantitative predictions from a familial environmental or genetic hypothesis, regarding the degree of resemblance to be expected between such pairs of adopted and non-adopted siblings on any given measure, will to some extent depend on the parameters included and on the assumptions made. Heuristi-

cally, however, the following simplification may be proposed in terms of expected intraclass correlations (ρ): a strictly environmental hypothesis would predict zero correlations among all separately reared pairs and a positive correlation between those reared together corresponding to that found in intact families, for example, usually about 0.5 for IQ¹; a strictly genetic hypothesis of polygenic transmission, by contrast, would predict correlations corresponding to the average proportion of shared genes, that is, 0.5 for full siblings, 0.25 for half-siblings, and 0.0 for unrelated individuals. These two hypotheses are extremes, and intermediate results would indicate the presence of both environmental and genetic influences.

The most fundamental assumption of an adoption study is that genetic and familial environmental factors are independent of each other in adoptees. We have no evidence to the contrary in the present study. The genetically related adoptee sibling pairs (FA, MA and PA) were reared in familial environments which, as measured by paternal income and social class, were uncorrelated (see Table 1); correspondingly, the absence of a correlation in social class between the biological fathers of the unrelated pairs (UT) fails to suggest that the pair members are genetically correlated.

The intraclass correlations ($\hat{\rho}$) for height, BPP and EL for each of the five groups, and for the two half-sibling groups combined, are shown in Table 2. We included height on the expectation that, whatever relationships emerged for BPP and EL, this variable would show a clear pattern of heritability. Although some genetic influence is evident, it appears anomalous that the correlation for the MA group should lie, albeit non-significantly, above that for the FA group while that for the PA group should be effectively zero. This may probably be attributed to the small group sizes and necessitates caution in interpreting our other findings.

The correlations for the BPP form a pattern conforming closely to the proposed genetic hypothesis. There are no reported studies of separately-reared adult full or half-siblings with which these results may be compared, but the only previous study of genetically unrelated adults reared together has also reported a negligible correlation (-0.03)⁸.

Studies of adoptive children have usually shown a lesser degree of genetic influence, and a correspondingly stronger familial environmental influence, on intelligence¹: perhaps both vary with age. In particular, one might expect that not all genetic effects would yet be manifested by the still-developing brain of a child⁹.

The correlations for educational level in the FA, MA and PA groups suggest a lesser degree of genetic influence on this variable and, conversely, the correlation for the UT group demonstrates a marked familial environmental effect. The latter correlation may reflect influences on scholastic aspirations and diligence. The high correlation for the FT group could thus be a result of the additive effect of both genetic and familial environmental influences.

Although the intraclass correlation remains a familiar statistic, it yields less information than a direct consideration of the within- and between-group mean squares, MS_w and MS_b , respectively, from which it is derived. We have therefore also fitted biometrical genetic models to MS_w and MS_b , using maximum likelihood^{11,12}. In a restricted model, the total variance consists of genetic variance, G , and environmental variance, E . For each sibling pair type, total variation (σ^2) is partitioned into 'within' and 'between' components: $\sigma^2 = \sigma_w^2 + \sigma_b^2$. The expectations for these components may be derived in terms of additive genetic variance, D_R , within-family environment, E_1 , and between-family environment, E_2 (ref. 11). Expected values for the observed mean squares may be readily obtained as $E(MS_w) = \sigma_w^2$ and $E(MS_b) = \sigma_a^2 + 2\sigma_e^2$ for sibships of size = 2. Table 3 gives the expected values. Assumptions in the model are: (1) no genotype-environment interaction, (2) no genotype-environment covariance, (3) $G = 1/2 D_R$, and (4) E_1 and E_2 values are the same for all types of sibship. We have no direct test of assumption (1) in these sibships. Assumptions (2)–(4) are jointly tested by

Table 1 Means and intraclass correlations ($\hat{\rho}$) for adoptive and biological fathers' income and social class

	Annual income (×1,000 kroner)					Social class				
	No. of pairs	Mean	MS_b	MS_w	$\hat{\rho}$	No. of pairs	Mean	MS_b	MS_w	$\hat{\rho}$
Adoptive fathers										
Full sibs apart (FA)	25	5.587	7.611	11.014	-0.22	27	2.37	2.523	2.704	-0.07
Maternal half-sibs apart (MA)	32	4.524	6.397	5.377	0.05	32	2.41	2.788	1.781	0.19
Paternal half-sibs apart (PA)	26	5.073	7.361	7.980	-0.08	29	2.62	2.523	3.690	-0.22
Half-siblings apart (MA and PA)	58	4.770	6.860	6.544	0.01	61	2.51	2.642	2.689	-0.03
Unrelated reared together (UT)	22	7.202				24	4.21			
Biological fathers										
Unrelated reared together						15	1.33	1.405	1.933	-0.23

The intraclass correlation coefficient (ρ) is estimated as $\hat{\rho} = (MS_b - cMS_w) / (MS_b + cMS_w)$ where $c = d.f._w / (d.f._w - 2)$. $d.f._w = N$ pairs. Being an estimate of a ratio of variances, a negative intraclass correlation is not meaningful. The negative values in the table are those obtained from the unbiased estimator and the best estimate in the range would be $\hat{\rho} = 0$. Details of paternal income and social class were obtained from the adoption records. Income was not recorded for the biological fathers. Social class is based on a rating scale of occupation in which 0 = low and 7 = high⁴. Both income and social class are missing in some cases and the values given are derived from all available complete pairs. The mean values are for all included fathers, that is, twice the number of pairs, except for the adoptive fathers for the UT group for whom the two potentially different values, one relating to each adoption, have been averaged. Analysis of variance (ANOVA) of the adoptive fathers' means for the FA, MA, PA and UT groups yielded $F(3,184) = 4.00$, $P < 0.009$ for income, and $F(3,196) = 8.38$, $P < 0.001$ for social class. Multiple range tests (Newman-Keuls, $\alpha = 0.05$) show, for income, $UT > MA$ and $UT > PA$, and, for social class, $UT > FA$, $UT > MA$, and $UT > PA$. Note also that we have reported elsewhere¹¹, for a different but comparable sample from the adoption register, that the paternal social class of adoptees, while being on average above that of the general population, does not display a smaller variance, that is, adoptees in general were raised in a representative range of social class environments.

Table 2 Means and intraclass correlations ($\hat{\rho}$) for siblings' height, intelligence (BPP) and educational level (EL)

	No. of pairs	Height (cm)				BPP				EL			
		Mean	MS_b	MS_w	$\hat{\rho}$	Mean	MS_b	MS_w	$\hat{\rho}$	Mean	MS_b	MS_w	$\hat{\rho}$
Full sibs apart	28	174.7	43.87	23.66	0.27	33.38	257.50	85.16	0.47‡	3.91	7.335	3.089	0.38*
Maternal half-sibs apart	34	175.3	63.67	28.12	0.36*	32.47	122.57	91.71	0.11	3.65	2.380	3.912	-0.27
Paternal half-sibs apart	30	175.7	31.23	34.67	-0.09	35.17	154.53	77.97	0.30*	4.13	4.446	2.667	0.22
Half-sibs apart	64	175.5	48.09	31.13	0.20*	33.73	139.02	85.27	0.22*	3.88	3.413	3.328	0.00
Unrelated reared together	24	177.0	36.69	31.42	0.03	37.75	157.22	138.88	0.02	4.96	6.214	2.292	0.43†
Full sibs reared together	73	187.5	11.24	7.25		40.59	228.87	70.45	0.52§	4.95	7.225	1.404	0.67§

Being an estimate of a ratio of variances, a negative intraclass correlation is not meaningful. The negative values in the table are those obtained from the unbiased estimator (see Table 1), and the best estimate in the range would be $\hat{\rho} = 0$. The PA and MA & PA values for height are based on 29 and 63 pairs, respectively. Height was not recorded for one of the adoptees in the PA group; $\hat{\rho}$ is not calculated for the FT group because of the range restriction—all individuals were ≥ 184 cm. ANOVA for the four adoptee groups (FA, MA, PA and UT) yielded $F(3,228) = 4.32$, $P < 0.006$ for EL, and a multiple range test (Newman-Keuls, $\alpha = 0.05$) shows $UT > FA$, $UT > MA$ and $UT > PA$. For BPP the overall comparison is not significant, $F(3,228) = 2.22$, $P > 0.09$, but an *a priori* comparison shows that the UT group is higher than the FA, MA and PA groups combined: $t(228) = 2.18$, $P < 0.03$.

* $P < 0.05$; † $P < 0.01$; ‡ $P < 0.005$; § $P < 0.001$.

Table 3 Expected mean squares for biometrical genetic model

		D_R	E_1	E_2
Full sibs apart	MS_w	1/4	1	1
	MS_b	3/4	1	1
Maternal half-sibs apart	MS_w	3/8	1	1
	MS_b	5/8	1	1
Paternal half-sibs apart	MS_w	3/8	1	1
	MS_b	5/8	1	1
Unrelated reared together	MS_w	1/2	1	0
	MS_b	1/2	1	2
Full sibs reared together	MS_w	1/4	1	0
	MS_b	3/4	1	2

D_R , Additive genetic variance; E_1 , within-family environmental variance; E_2 , between-family environmental variance.

Table 4 Biometrical genetic models

Parameter	Estimate $\pm$ s.e.	z	d.f.	Model fit	
				χ^2	P
Height model					
D_R	53.349 ± 21.73	2.45*			
E_1	7.321 ± 12.49	0.59			
E_2	3.259 ± 7.62	0.43	5	5.2857	0.3820
BPP model					
D_R	256.20 ± 66.23	3.87†			
E_1	3.95 ± 19.97	0.20			
E_2	6.15 ± 15.99	0.38	7	4.6248	0.7056
EL model					
D_R	4.162 ± 1.818	2.29*			
E_1	0.324 ± 0.537	0.60			
E_2	1.655 ± 0.478	3.46†	7	7.8416	0.3468

* $P < 0.05$; † $P < 0.001$.

the homogeneity of the total variances across sibling types (height $F_{\max}(4, 56) = 1.38$, not significant (NS); BPP $F_{\max}(5, 64) = 1.59$, NS; EL $F_{\max}(5, 64) = 1.64$, NS), and also by the goodness of fit of the models ($P > 0.34$). Assumption (2) can also be tested by the equality of the total variance of biological siblings reared together and the pooled variance of the siblings reared apart (BPP $F_{\max}(2, 161) = 1.16$, NS; EL $F_{\max}(2, 161) = 1.10$, NS).

For all three variables the model provides an adequate fit with additive genetic variance significant in all cases (see Table 4). Between-family environmental variance is significant for EL only. Biometrical genetic modelling allows estimates of the effects of dominance deviation and assortative mating^{10,11,14}; the results of the goodness-of-fit tests imply non-significance for both parameters in these data.

Some degree of familial environmental effect on intelligence and educational level can be detected in the means of the four adoptee groups. The adoptees in the UT group were reared in homes that were significantly wealthier and of a higher social class than those in the other three adoptee groups (see Table 1). Parents adopting more than one child were better situated than adoptive parents in general; this has elevated the intelligence and educational level of their adoptive children. Compared with the FA, MA and PA groups, the UT group adoptees have a significantly higher BPP and EL, the latter effect being more marked than the former (see Table 2). The mean differences in EL and BPP between the adoptees taken together (FA, MA, PA and UT) and the non-adopted siblings (FT) are not easily interpreted as either or both groups may deviate from the general population, and genetic or environmental differences may be involved.

The correlation between BPP and EL is 0.65 for all adoptees and 0.71 for the non-adopted siblings; this replicates the strong relationship usually found between intelligence and educational level¹². These two variables are generally thought to interact

with each other. As our findings suggest stronger genetic effects on intelligence than on educational level, it could be that genetic influences on educational level are indirect and operate primarily through genetic effects on intelligence. Conversely, however, the effects of familial environment on educational level appear stronger than the effects on intelligence. Therefore, the effect of familial environment on intelligence might be the indirect result of a direct influence of education itself on intelligence. In view of the comparatively small sample sizes used in the present study, and the (perhaps consequent) paradoxical findings for height, this interpretation must only be tentative.

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